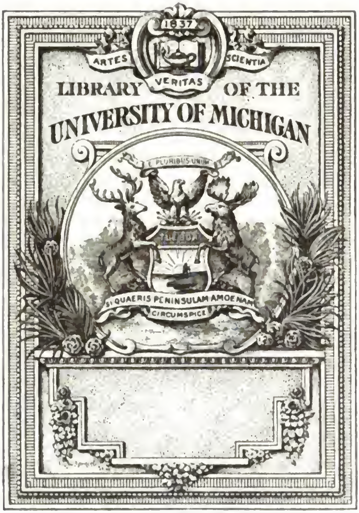
Monthly notices of the Royal Astronomical Society

Royal Astronomical Society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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY,

CONTAINING

PAPERS,

ABSTRACTS OF PAPERS,

AND

REPORTS OF THE PROCEEDINGS

OF

THE SOCIETY,

FROM NOVEMBER 1867, *TO JUNE* 1868.

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VOL. XXVIII. 28

BEING THE ANNUAL HALF-VOLUME OF THE MEMOIRS AND PROCEEDINGS
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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *November* 8, 1867.-8 No. 1.

Rev. Charles Pritchard, M.A., President, in the Chair.

Thomas Michael Almond, Esq., Scarborough;
Samuel Courtauld, Esq., Gosfield Hall, Essex; and
Edwin Story, Esq., Alnwrah Road, Islington,
were balloted for and duly elected Fellows of the Society.

Volumes XXXV. and XXXVI. of the *Memoirs* are now published. Vol. XXXV., price to Fellows, 14*s.*; to the public, 25*s.* Vol. XXXVI. (without *Monthly Notices*) to Fellows gratuitously. Price of ditto (with *Monthly Notices*) to the public, 10*s.* Pursuant to a recent Resolution of the Council, each Fellow is entitled to receive a copy of Vol. XXXVI. and of every subsequent volume of the *Memoirs*, on *personal* application by himself or his agent, at the Apartments of the Society, provided that such application is made within three years from the end of the year in which the volume is published.

The Annual Parallax of Sirius deduced from North Polar Distances observed with the Transit-Circle at the Royal Observatory, Cape of Good Hope, 1856–1863. By Cleveland Abbe, Esq.

This fine series of meridional observations, of which 136 are direct and 12 reflexion, is divided as follows:—

1856	25 D	7 R	1858	4 D	1860	33 D	5 R	1862	21 D
1861	2 D		1859	2 D	1861	8 D		1863	41 D

The observers and the share that each has taken in the work are shown by the following:—

Sir Thomas Maclear	34	observations	T. D.	1	observation.
			G. C.	14	,,
George Maclear	61	,,	C. D. F.	25	,,
William Mann	6	,,	J. F.	7	,,

The crude observations are not at hand, but instead thereof, a series of corresponding mean N. P. D.'s for the beginning of each year; these numbers are presumed to have been obtained by adding to the mean declination of the *British Nautical Almanac* the difference between the tabular and observed apparent declination. Nothing has been communicated concerning the methods of observation and reduction.

It is proposed to reduce these N. P. D.'s to the mean equinox of 1860·0, using the variable proper motion resulting from the investigations of Dr. Auwers, as published in No. 1506 of the *Astronomische Nachrichten*. Dr. Auwers has given his results in the form of corrections to the mean distances of Bessel's *Tabulæ Regiomontanæ*, using Zech's continuation of the *Tab. Reg.* for 1850–1860, and Wolfers' *Tabulæ Reductionum* for 1860–1880, minus the corrections given in his Introduction. We thus receive the following system of mean declinations:—

	Auwers.		British Naut. Alm.	
Year.	Mean δ,	Red. to 1860·0.	Mean δ,	Red. to 1860·0.
1856	−16° 31′ 19″·231	−18″·923	−16° 31′ 19″·70	−18″·46
1857	23·953	−14·201	24·32	−13·84
1858	28·682	− 9·472	28·93	− 9·23
1859	33·417	− 4·737	33·54	− 4·64
1860	38·154	0·0	38·16	0·0
1861	42·898	+ 4·744	42·78	+ 4·62
1862	47·644	+ 9·490	47·40	+ 9·24
1863	52·391	+14·237	52·03	+13·87

The mean δ from the *Nautical Almanac* for 1856 has received the correction $+0''\cdot02$ to reduce it to Jan. 0 $\odot = 280°$. The comparison of the annual variations deduced from the declinations of Auwers and the *Almanac* shows that we must add to each individual mean declination the correction $+0''{\cdot}12\,\tau$, in order to reduce it to the beginning of the year with Auwers' proper motion We thus have as the foundation of further investigations,

$$\text{Given mean } \delta + (0''{\cdot}02 \text{ for } 1856) + 0''{\cdot}12\,\tau + \text{Auwers' Reduction to } 1860{\cdot}0$$
$$= -16^\circ\ 31'\ 36''{\cdot}20 + \text{function of parallax and other unknown quantities.}$$

Our first inquiry should now be, how far the given observations are free from constant errors that will undermine the security of any resulting value of the desired Parallax. Knowing but little of the methods pursued by the different observers, it is evident that each must be supposed to have a different constant error, whilst the corrections to the proper motion and the constant of aberration should be zero. The correction of the thermometer coefficient in the refraction will be assumed zero for want of proper material to determine it. Our equations of the condition should therefore be of the form

$$\text{Mean } \delta\ 1860{\cdot}0 = +16^\circ\ 31'\ 36''{\cdot}20 + x_1 + x_2 + x_3 + x_4 + y\,[9{\cdot}8065] \sin(\odot - 4^\circ{\cdot}3)$$
$$+ z\,(t - 1860{\cdot}0) + w\,[9{\cdot}8065_n] \cos(\odot - 4^\circ{\cdot}3)$$

or

$$0 = n + x_1 + x_2 + x_3 + x_4 + a\,y + b\,z + c\,w,$$

x_1, x_2, x_3, x_4 being the constant corrections for G. M., T. M., G. C., C. D. F., respectively: y the parallax, z the correction to the proper motion, w the correction to the aberration $20''{\cdot}45$.

Our observations are not sufficient for the determination of so many unknowns, and we will make a first solution, omitting $b\,z$ and $c\,w$. We have the following normals:—

$$\begin{aligned}
61\,x_1 - 1{\cdot}32\,y + 8{\cdot}71 &= 0 \\
34\,x_2 + 8{\cdot}35\,y - 2{\cdot}00 &= 0 \\
14\,x_3 - 4{\cdot}99\,y + 4{\cdot}06 &= 0 \qquad [n\,n] = 104{\cdot}21 \\
25\,x_4 - 7{\cdot}19\,y - 23{\cdot}25 &= 0 \\
-1{\cdot}32\,x_1 + 8{\cdot}35\,x_2 - 4{\cdot}99\,x_3 - 7{\cdot}19\,x_4 + 33{\cdot}61\,y - 1{\cdot}72 &= 0
\end{aligned}$$

whence I.

$$\begin{aligned}
x_1 &= -0{\cdot}136 \quad \pm 0{\cdot}058 \\
x_2 &= +0{\cdot}006 \quad {\cdot}080 \\
x_3 &= -0{\cdot}209 \quad {\cdot}124 \\
x_4 &= +0{\cdot}995 \quad {\cdot}093 \\
y &= +0{\cdot}227 \quad {\cdot}084
\end{aligned}$$

$$\text{Prob. error of one observation} = \pm 0{\cdot}450$$

The observations of Mr. George Maclear are also alone sufficiently numerous to authorise an independent solution. We have the normals

$$61\,x_1 - 1{\cdot}32\,y + 8{\cdot}71 = 0$$
$$-1{\cdot}32\,x_1 + 15{\cdot}47\,y - 6{\cdot}99 = 0 \qquad \text{II.}$$

whence

$$x_1 = -0{\cdot}133$$
$$y = +0{\cdot}440$$

The computation of the residual errors from the solution I. gives us

Prob. error	1 observation	G. M.	61 obs.	± 0″·46
		T. M.	34	0·26
,,	,,	G. C.	14	0·39
		C. D. F.	25	0·78
,,	,,	C. D. F.	24	0·65

This second value for C. D. F. being found by omitting the observation of 1863, Jan. 21, whereof the discordance −3″·46 is much larger than should be attributed to the accidental errors of good observers. We have in this solution given the same weight to all observers and observations. There are twenty-one cases in which the image of the star is noted as very bad, execrable, a mere blotch, &c. Collecting these, we find,

Prob. error	1 obs.	bad image	± 0″·50
,,	1 obs.	ordinary	± 0·48

The above Annual Parallax seems to be the most reliable that can be drawn from the given observations; and if we compare its value + 0·227 ± 0″·084 with that drawn from the observations of Maclear in 1836–37 by Dr. Gylden,* — viz., + 0″·193 ± 0″·087, we find the agreement sufficiently satisfactory. But the latter value is entitled to greater confidence, inasmuch as the zero point of the circle was eliminated by the direct and reflexion observations.

That constant errors have been present in the series now under consideration, and which may have exerted a prejudicial influence upon the resulting parallax, will be suspected from the following solution. We combine, namely, all the 148 observations, the equations of condition being of the form

$$0 = n + x + ay + bz + ew,$$

where the personal differences are considered as smaller than their probable errors.

---

* *Bulletin de l'Académie Impériale des Sciences de St. Petersbourg*, 1864, April.

We obtain then the following normals:—

$$\begin{array}{rrrrrl} 148\,x & -10.48\,y & +\ 118.52\,z & -28.96\,w & -17''.49 & =0 \\ -\ 10.48 & +36.55 & -\ \ 62.37 & +14.62 & -\ 0.04 & =0 \\ +118.52 & -62.37 & +1001.58 & -17.80 & -71.97 & =0 \qquad [nn]=112.32 \\ -\ 28.96 & +14.62 & -\ \ 17.80 & +24.36 & +\ 8.22 & =0 \end{array}$$

whence **III.**

$$\begin{array}{ll} x=-0''.029 & \pm 0''.056 \\ y=+0.350 & \quad .116 \\ z=+0.078 & \quad .0201 \qquad\qquad [nn4]=102.24 \\ w=-0.517 & \quad .153 \end{array}$$

Prob. error 1 obs. $= \pm 0.562$

The large corrections to the aberration and proper motion, as well as the large parallax, may serve to render these results inadmissible. A portion of the entire change in the value of the parallax may be due to the large personal error of C. D. F. For the other observers our hypothesis $x_1 = x_2 = x_3$ may be admitted; and in general we may notice that the entire series will be better fitted to the determination of parallax and aberration if the year 1863 is omitted, as its observations are all included in the first three months. Omitting these observations (including more than one half of those made by C. D. F.) and retaining the same unknowns, we have

$$\begin{array}{rrrrrl} 1.07\,x & +\ 4.88\,y & -\ \ 9.30\,z & -11.35\,w & +0''.78 & =0 \\ +\ 4.88 & +28.50 & -\ \ 14.75 & +\ 9.37 & -8.95 & =0 \qquad [nn]=50.191 \\ +\ 9.30 & -14.75 & +602.68 & +37.49 & -9.84 & =0 \\ -11.35 & +\ 9.37 & +\ \ 37.49 & +15.62 & +0.17 & =0 \end{array}$$

whence **IV.**

$$\begin{array}{ll} x=-0''.084 & \pm 0''.046 \\ y=+0.560 & \quad .102 \\ z=+0.0622 & \quad .0210 \qquad\qquad [nn]=44.59 \\ w=-0.546 & \quad .154 \end{array}$$

Prob. error 1 obs. $= \pm 0.438$

The aberration and proper motion corrections being properly considered only as tests, unless we give attention to the newly published investigations of Dr. Klinkerfues, we shall derive our most reliable value of the unknowns x and y from the preceding equations, by neglecting the other two, z and w.

We thus have **V.**

$$\begin{array}{ll} x=-0''.022 & \\ y=+0.318 & \pm 0.08 \qquad [nn2]=47.33 \end{array}$$

The proper result for parallax will, however, be that of solution I., or perhaps still better, a similar solution in which $x_1 = x_2 = x_3$ is assumed. We thus have

$$\begin{array}{rrrrl} 109\,x_1 & & +\ 2.04\,y & +10''.77 = 0 & \\ & 25\,x_4 & -\ 7.19\,y & -23.25 = 0 & nn = 104.21 \\ +204\,x_1 & \pm 7.19\,x_4 & +33.61\,y & -\ 1.72 = 0 & \end{array}$$

whence

$$\begin{array}{lrrl} & x_1\ -0''.102 & \pm 0''.056 & \\ & x_4\ +1.008 & 0.132 & [nn\,3] = 79.17 \\ & y\ \ +0.273 & 0.102 & \\ \text{Prob. error 1 obs.} & & \pm 0.576 & \end{array}$$

previously where we have neglected such constant errors as are manifested by the results of the III. and IV. solutions.

The result of our investigations is, therefore, to be considered as at least corroborative of the conclusion drawn by Mr. Henderson, as given in his Memoir in vol. xi. of the *Memoirs of the Royal Astronomical Society*, that "the parallax of *Sirius* is not greater than one-half of a second of space," the precise statement being

$$\pi = +0''.27 \pm 0''.10$$

Poulkova, May 1866.

On some newly discovered Stars near α Lyræ.
By J. Buckingham, Esq.

About four years since, during a visit by Mr. Hartnup, when looking through my 20-inch object-glass (made by Wray), which is mounted equatoreally, we perceived a very small, yet bright, star near *Vega*, which appeared precisely situated on an imaginary line from A to B, the well-known companion; but, owing to the state of the air, it could only occasionally be seen. It has been repeatedly verified since.

In the autumn of 1865 its brightness had much increased, and it was more easily seen than at the time of its discovery, yet not sufficiently so to be perceived with my 9-inch object-glass (also by Wray), which is as fine as possible, in my opinion, to be made; its focus is 14½ feet. This star *c* since the earlier part of August is fainter than before observed, and its position-angle has increased since its discovery, being now (November) to the S.W. of the former place, which was on the line from A to B, but now sensibly to the apparent left of it, its distance appearing to be about $\frac{1}{8}$ that of B from A.

On the 10th May, 14^h P.M., 1867, with the same object-glass (20-inch) another small star *d* was perceived, about 90° or 95° greater in its position-angle than the star *c*; also rather more distant and not so bright as it; and only seen by glimpses during moments of fine definition; but I could not perceive either *c* or *d* with the 9-foot Equatoreal.

On July 19 last, my friend, the Rev. R. Crowe, of Huddersfield, was looking at *α Lyræ* through the 9-foot Equatoreal (driven by the Foucault clock), and had only a short time been so occupied when the star *c* was seen, of which he made a diagram by my request; and the estimated distance from A was $\frac{1}{7}$ of that of B. After a few more moments he perceived the star *d*, and placed its position on the previous diagram, when I showed him my own previous sketch, and they perfectly accorded so far as to be seen that they were the same objects. Mr. Crowe had not received the slightest intimation of my known positions; but to him they were "easily seen:" for myself, had I not known of the previous existence and positions, it is probable they would in this instrument have been overlooked. Although there was not the slightest perceptible tremor of the atmosphere, the images being absolutely steady, every known precaution was taken to avoid the chance of error, as various eye-pieces were used, and were rotated, as well as the object-glass; and the instrument was used several times on each side of the polar axis with like results. It was necessary to use powers of 250 and upwards, the two stars not being visible with lower ones; but being best seen with 440.

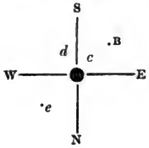
On August 10, 1867, some visitors (well-known good observers) looked through the new 21½-inch object-glass. The air was rather unsteady, with considerable "flying scud," yet they each could see both stars *c* and *d*. They left about 11 P.M., as the atmosphere prevented further observation, it being entirely clouded over. Some time after they had left the Observatory, the night cleared up, and became brilliant,—perhaps more so than usual in my experience,— and I was induced to go again to the large telescope to examine some nebulæ. After some time I again turned the instrument on *α Lyræ*, and directly perceived another new star *e*. As *a* entered the field of the eye-piece, it was north, preceding, at an angle about 295°, distance about 34 seconds or more of arc. It had at least three times the light of the others *c* and *d*, and was best seen with powers 630 and 850, appearing of purple tint; and about the brilliance of the pole-star companion in a 3-inch aperture and power 100, but it has since become brighter.

c is brighter than *d*, but they are both too faint for estimation of colour by myself, and can only be seen in a tolerably good state of the air; and I estimate their brilliance in the large object-glass as little exceeding that of the companion of *Polaris*, as seen by myself with a power of 80 in an object-glass of 1·7 inch aperture,— that is, just steadily visible now (in November).

The few succeeding remarks may be necessary to show why the larger instrument was not used during Mr. Crowe's observations; having just had a new object-glass of 21¼ inches made, and for the purpose of testing its quality.

In the beginning of July last the former object-glass of 20 inches was taken out of its cell, which latter was temporarily adapted to the new and larger object-glass, which was tried on July 8th, and its performance being found excellent, with powers up to 1800, there being fine definition on suitable objects, as γ^2 *Andromedæ*, γ *Equulei*, δ *Cygni*, ζ *Herculis*, and the excessively faint double star near A and B *Capricorni*, I decided to alter the old tube and reduce its length to that of the new object-glass, viz. 25⅔ feet; which alterations were not complete till July 28th; so that I had no larger instrument in use, at the time Mr. Crowe paid me a visit, than the 9-inch Equatoreal; but since the end of July, this 21¼-inch object-glass has been used on every night since that opportunity gave me, and its performance is very satisfactory on double stars; equally so on nebulæ; and in the "Dumb Bell" many stars are readily visible on its surface. The detail on the Moon is remarkable; the smaller satellites of *Uranus* are pretty bright: that of *Neptune* has been observed. The 5th and 6th stars in the trapezium of *Orion* are wonderfully bright objects, and the detail and brilliance of the nebula itself astonishing.

Rough Diagram of Positions.



The discovery of these minute points of light near a star, so often under the scrutiny of nearly every observer, will doubtless interest most of our Members, as there are many instruments in this country capable of reaching these specks under favourable circumstances, independently of any speculations as to their physical connexion with A; and the belief that a report of the performance of so large an object-glass of English manufacture would be desirable to be known to our Society, is my apology for the length of this communication.

November 8, 1867.

Description of an Observing Chair. By the Rev. W. R. Dawes.

I beg the Society's acceptance of a few copies of a photographic picture of an observing chair, which I contrived and had made some years ago. I have found it more convenient and useful than any other I have ever met with of moderate size and expense.

The general plan of its construction will be obvious from the picture. A few points may require a little further explanation.

The angle of the slanting upper part of the frame is about 30°. The left-hand slanting timber is notched throughout its length; and, attached to the sliding body composed of the seat and back, is a stout catch which falls into the notches as the chair is raised; and, when lifted up by the left hand of the observer, permits the chair to descend.

The back is supported by a stout quadrant of iron, toothed on the under side; and a catch is forced by a spring into the teeth as the back is raised, to support it at any convenient elevation. The catch can be easily pushed out of the teeth by the observer reaching behind him with one hand, while he diminishes the elevation of the back with the other.

On the right-hand side of the back is an arm which can be raised or lowered at pleasure, so as to prevent fatigue to the right arm by supporting the elbow, and to keep the hand steady in the management of the micrometer.

The angle which the slanting frame makes with the horizon is arranged so that when the seat is raised nearly to the top, the observer's eye may be at about the same height from the floor as it would be if he were standing. Of course, the angle may be varied with regard to the distance of the pillar of the equatoreal from the wall of the room, and to the height of the declination axis above the floor.

On the left side, attached to the upright timber near the middle of the frame, is a long and stout bolt, having a sharp point, which is so arranged as to be quite free from the floor when entirely drawn up, and so pierce the floor when forcibly pushed down. This enables the observer to *cast anchor*, and prevents the chair from being accidentally moved from the most convenient place.

The first chair of this kind was made at Wateringbury when I was residing there; but during my residence at Haddenham, several have been made here under my superintendence for some eminent observers. One of them is in the Royal Observatory at the Cape; and, as I have been informed, is highly esteemed by Sir Thomas Maclear; and one is now in hand for our Secretary, Mr. Huggins. The simplicity of their construction renders it almost impossible for them to get out of order, as is proved by the fact, that the first which was made, about fifteen years ago, and has been in constant use the whole time, has never needed any repair, and now works as well as ever.

Hopefield Observatory, Haddenham, Bucks,
1867, *Nov.* 6.

P.S. To render the different parts more distinct, I have drawn the following sketches.

Fig. 1.

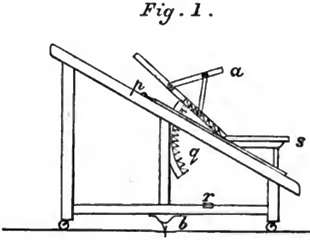


Fig. 1. *Right Side.*

a. ***Arm***, for supporting the observer's elbow at any convenient height.
b. ***Bolt***, for anchoring. Sharp point *pushed into floor.*
p. ***Pin***, by pressing which the spring is pushed out of the teeth of the the *quadrant p.*
r. ***Rail*** across the lower frame for supporting the feet. May be removed if ever in the way of the iron quadrant *q.*

Fig. 2.

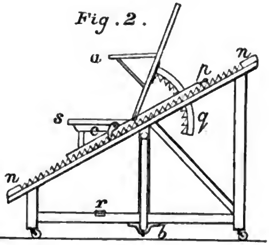


Fig. 2. *Left Side.*

a. See Fig. 1.
b. ***Bolt***, as fixed on the middle upright timber; represented as *drawn up.*
c. ***Catch***, which falls into the notches (*n n*) in the slanting timber, and supports the seat (*s*).
p. See Fig. 1.
q. Iron toothed *quadrant.*
r. See Fig. 1.

Jupiter without a visible Satellite. By the Rev. W. R. Dawes.

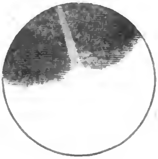
On the evening of August 21st, clouds prevented observations of the planet till the fourth satellite was very near the eastern edge of the disk. Its light was small and its colour rather ruddy. The first satellite, which was near it, had two or three times the light of the fourth. Clouds prevented observation of the entrance of the fourth upon the disk. It was a little past 10^h before the planet was moderately well seen. The third, fourth, and first satellites were then all visible on the disk, together with their shadows.

In the best state of the atmosphere I found power 412 the most efficient on my 8-inch refractor. Watching for the best views with this power, I carefully examined each of the six objects visible on the disk.

Contrary to my expectation, the shadows of all the three satellites appeared to be equally black throughout. Not even on that of the fourth could I perceive any deviation from perfect blackness up to the very edge; and this precisely agrees with the results of all my previous observations; in which, however, I had not so carefully attended to this point. That there ought to be a sensible penumbra seems to be evident; but it has occurred to me since the observation, that the reason why it is not perceivable may be, that the edge of the shadow is in immediate contrast with the bright surface of the planet; and therefore, though not quite so black as its centre, it appears so by contrast.

The *fourth* satellite was so dark that I could not satisfy myself that it was decidedly less dark than its shadow. Nor could I be sure of any variation of tint in different parts of the satellite, or of any obvious deviation from perfect roundness. Indeed it could only be distinguished from its own shadow by its smaller size. That there should be no irregularities observable in the dark shade of this satellite surprised me much, as I have formerly noticed such without great difficulty.

The careful scrutiny of the *third* satellite furnished a very different result. The north-eastern side of it was remarkably bright, while the opposite side was nearly as dark as its shadow. Usually the satellite seemed to be about equally divided between the bright and dark portions; but during the finest views the true form of the dark part came out with satisfactory distinctness; and it then forcibly reminded me of the form which I had on more than one occasion depicted. (See *Monthly Notice*, April 1860, figs. 2 and 3). But it occupied an almost directly opposite part of the satellite, namely, the south-west instead of the north-east; thus,—



Occasionally the narrow white channel between the two dark protuberances was clearly seen, though by too transient views.

Hopefield Observatory, Haddenham, Bucks,
1867, *Nov.* 6.

P.S. The substance of this paper, with the illustrative sketch of the third satellite, has already appeared elsewhere, because it was important that, if possible, the remarkable appearance of the satellite should be looked for during every transit which would occur in the present apparition, by all observers who possess sufficiently powerful telescopes.

On Jupiter without Satellites exterior to his Disk.
By T. W. Burr, Esq.

Being desirous of witnessing the appearance above referred to, I visited my friend Mr. Slack, of Camden Square, N.W., on the night of August 21st, he having in his Observatory an excellent 6½-inch silvered glass mirror, mounted equatoreally by Mr. Browning. Unfortunately the weather was most unfavourable,— dense masses of clouds obscuring the heavens; and it was not until nearly 10 o'clock that a break occurred, enabling us to see the planet with only one satellite (the 1st) remaining outside the disk. The shadows of two others (the 3d and 4th) were also seen projected on the southern equatoreal belt with another, not so well defined, object between them. Soon after 10 o'clock a second glimpse was obtained, and the 1st satellite seen just entering on the disk of *Jupiter*. A few more fleeting views were caught between $10^h 20^m$ and $10^h 30^m$, during which it was evident that the object seen between the shadows was the 3rd satellite itself; and that it was lighter in tint than the shadows, which were inky black, the satellite giving the impression of a browner colour. The shadow of the 1st satellite was also now visible, as black as the others, and not being thrown on a belt like those of the 3d and 4th, but on a clearer space, was very conspicuous. The clouds then closed up so thickly that no further observations could be made during the time the transits and occultation continued. Four spots, being three shadows and one satellite (the 3rd), were therefore distinctly seen, and, as I subsequently had a difficulty in localizing the shadow of the 1st satellite, my memory giving the impression of a spot both above and below the southern equatoreal belt, I have no doubt that at times I also perceived, in my hasty glimpses through the drifting clouds, the 4th satellite itself; which, if so, was as black as the shadows, and unlike the 3rd in its lighter tint. The power employed was 120, with the occasional change to 175; and the performance of the telescope, during the brief opportunities for observation, most excellent.

Islington, October 1867.

Determination of the Latitude of Kingston Observatory, Canada.
By the Rev. Dr. J. Williamson.

Having a portable transit 30 inches in length, I wished to employ it in correcting our roughly determined latitude; but our building not being fitted for observation in the prime vertical precluded the possibility of employing that method within doors, while the situation of the Observatory, in a public park, was not such as to allow of using instruments out of doors. In this dilemma I resorted to the following method:—

The stand of the transit is supported by three foot-screws, one of which is directly beneath a Y of the instrument.

Beneath this foot-screw I adjusted a carefully made micrometer-screw, having a head divided into 100 parts.

I then determined the value of one division, partly by means of the level and partly by transits of stars, to be 0″·96.

I then carefully adjusted the instrument for collimation and placed the axis in the meridian as nearly as possible, the thread intervals being previously obtained.

I next computed from the B. A. C. the places of several stars which pass within a few minutes of our zenith, limiting myself to those which would be confined to the web of the transit, or nearly so. When one of these stars was upon the meridian I brought that wire of the instrument which was nearest to it to coincide with it by turning the micrometer-screw.

In this manner I determined the distance at which the star would, when culminating, pass from the middle wire of the instrument when in its zero position, and hence the latitude.

The results of the several observations for this purpose are given below.

Date. 1865.	Star. B.A.C.	Comps.	Ded. Latitude.	Weight.
June 8	4841	N	44° 13′ 26″·6	10
10	,,	S	24·7	8
12	5400	N	23·1	8
,,	4841	S	16·3	8
16	4841	S	17·6	7
19	5400	S	18·3	8
21	4841	N	20·7	10
22	4841	S	21·6	10
,,	5400	S	23·3	9
23	4841	S	23·3	10
Aug. 14	6731	S	21·9	10
15	6013	S	18·9	8
16	6013	N	24·7	7
19	6013	N	44 13 21·8	10

Giving a mean value

$$\varphi = 44^\circ\ 13'\ 21''{\cdot}7$$

with a probable error of 0″·7.

Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield. By Capt. W. Noble.

(Previously unreported.)

Friday, January 18, 1867, Occultation of 26 *Geminorum.*

The Star disappeared instantaneously at the Moon's dark limb at $3^{h}\ 34^{m}\ 38^{s}\cdot3$ L.S.T. = $7^{h}\ 43^{m}\ 40^{s}\cdot1$ L.M.T.

and reappeared at the bright limb at $4^{h}\ 39^{m}\ 21^{s}\cdot5$ L.S.T. = $8^{h}\ 48^{m}\ 12^{s}\cdot7$ L.M.T.

Power employed 135 on the micrometer.

Saturday, Sept. 7, 1867, Occultation of B. A. C. 6932.

The Star disappeared instantaneously at the Moon's dark limb at $20^{h}\ 55^{m}\ 20^{s}$ L.S.T. = $9^{h}\ 49^{m}\ 20^{s}\cdot5$ L.M.T.

The reappearance was not observed.

Power 154.

Sunday, Sept. 8, 1867, Occultation of ξ^{2} *Sagittarii.*

The Star disappeared instantaneously at the Moon's dark limb at $20^{h}\ 57^{m}\ 18^{s}\cdot6$ L.S.T. = $9^{h}\ 47^{m}\ 22^{s}\cdot9$ L.M.T.

The reappearance was not observed, the Moon, as in the last case, having descended behind some trees.

Power 135 on the micrometer.

Note on the Lunar Eclipse of Sept. 13, 1867. By Capt. W. Noble.

I of course observed the Eclipse of the Moon on the night of the 13th of September ult.; but a transcript of my notes would possess very little interest; mainly referring, as they do, to the times of immersion in, and emersion from, the Earth's shadow of the principal craters. Inasmuch, however, as Mr. Browning has stated that he failed to detect any *colour* in the shadow, either when employing a reflector or a refractor, I may just say that in my own 4·2-inch refractor, the shadow presented what an artist would call a warm grey tint; and at the period of the greatest phase, and for some time afterwards, the Moon's limb N. of *Aristarchus* presented a strong copper tinge, which was particularly marked about $12^{h}\ 42^{m}$.

Comet III. 1867.

Discovered 27th September by Herr Bäker, at Nauen, and 4 hours later by Dr. Winnecke. The following elements, calculated by Dr. Tietjen from Bonn and Vienna Observations of Oct. 1, and Berlin Observations of Oct. 10 and 17, are given, *Astron. Nach.* No. 1664:—

$$T = 1867,\ \text{Nov. } 6{\cdot}99920 \text{ Berlin M.T.}$$

$$\left.\begin{array}{rl} \pi - \Omega = & 148^\circ\ 36'\ 58''{\cdot}9 \\ \Omega = & 64\ \ 58\ \ 27{\cdot}1 \\ i = & 96\ \ 33\ \ 30{\cdot}5 \end{array}\right\}\text{ Mean Equinox } 1867{\cdot}0$$

$$\log q = 9{\cdot}519074$$

Minor Planet (92) Undina.

Discovered by Dr. C. H. F. Peters, at the Hamilton College Observatory, Clinton, U.S., July 9, 1867. The first observations were as follows:—

1867, July 7 $15^h\ 26^m\ 32^s{\cdot}5$ M.T. $\alpha = 21^h\ 20^m\ 51^s{\cdot}4$ $\delta = -21^\circ\ 31'\ 12''{\cdot}2$

by 10 comparisons with O. Arg. 2138; and the following morning, by 8 comparisons with the same star:—

1867, July 8 $15^h\ 20^m\ 0^s{\cdot}7$ M.T. $\alpha = 21^h\ 20^m\ 25^s{\cdot}94$ $\delta = -21^\circ\ 37'\ 24''{\cdot}2$

The following elements, calculated by Dr. Peters, are given, *Astron. Nach.*, No. 1665:—

Epoch 1867, Jan. 0·0 Berlin M.T.

$$M = 304^\circ\ 10'\ 16''{\cdot}2$$

$$\left.\begin{array}{rl} \pi = & 334\ \ 29\ \ 30{\cdot}8 \\ \Omega = & 102\ \ 50\ \ 56{\cdot}1 \\ i = & 9\ \ 56\ \ 22{\cdot}0 \end{array}\right\}\text{ Mean Equinox, } 1867{\cdot}0$$

$$\begin{array}{rl} \varphi = & 5\ \ 58\ \ 27{\cdot}5 \\ \mu = & 622''{\cdot}3906 \\ \log a = & 0{\cdot}5039624 \end{array}$$

The magnitude, October 4, being about 11·3.

Minor Planets (93) and (94).

No elements appear to be yet published of these last two Minor Planets discovered by Prof. Watson, Director of the Ann-Arbor Observatory, (93) August 24, and (94) September 6. The two planets were each of the magnitude 11.

ERRATUM.

Memoirs, Vol. XXXV.

In page 25, columns 5 and 6, of the Table, Comparison with Struve's Stars (Place by Chart for 1826) of Star, Struve 409, W. H. IV. 44,

For $3^{h}\ 31^{m}\cdot 3 \quad 70^{\circ}\ 48'$, *read* $3^{h}\ 21^{m} + \quad 70^{\circ}\ 15'\pm$.

CONTENTS.

	Page
Fellows Elected	1
Vols. XXXV. and XXXVI. of the *Memoirs*	ib.
The Annual Parallax of *Sirius* deduced from North Polar Distances observed with the Transit-Circle, 1856–1863, at the Royal Observatory, Cape of Good Hope, by Mr. Abbe	2
On some newly-discovered Stars near *α Lyræ*, by Mr. Buckingham ..	6
Description of an Observing Chair, by the Rev. W. R. Dawes	9
Jupiter without a visible Satellite, by the Rev. W. R. Dawes	10
On *Jupiter* without Satellites exterior to his Disk, by Mr. Burr	12
Determination of the Latitude of Kingston Observatory, Canada, by the Rev. Dr. Williamson	ib.
Occultations of Stars by the Moon, observed at Forest Lodge, Maresfield, by Capt. Noble	14
Note on the Lunar Eclipse of Sept. 13, 1867, by Capt. Noble	ib.
Comet III. 1867, discovered by Herr Bäker	15
Minor Planet (92) *Undina*, discovered by Dr. Peters	ib.
Minor Planets (93) and (94), discovered by Prof. Watson	ib.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *December* 13, 1867. No. 2.

Admiral R. H. Manners in the Chair.

The Earl of Rosse, Birr Castle, Ireland;
William Cotterell, Esq.. Walsal; and
David Gill, Esq., Aberdeen,

were balloted for and duly elected Fellows of the Society.

Note on the Total Solar Eclipse of 1868, *August* 17–18.

By G. B. Airy, Esq., Astronomer Royal.

It is perhaps deserving of notice that the path of the totally dark shadow in this great eclipse, between Africa and India, coincides through a large portion of its length with the courses of our mail-steamers between Aden and Bombay.

Under the new contract for the mail-conveyance (for early communication of the particulars of which I am indebted to the kindness of the Secretary of the Post Office), a mail-steamer is to leave Aden on August 16, and will be due at Bombay on August 23, and a mail-steamer is to leave Bombay on August 11, due at Aden (including the estimated effect of monsoon) on August 22. Both these steamers will pass through the dark shadow. The steamer from Bombay on August 18 will be starting nearly at the time of totality; but will not then be in the total darkness.

Although the motion of a ship destroys the possibility of making many of the most important of those observation which can be made on shore, yet various observations can be made well.

The red prominences which have been seen with the naked eye can certainly be seen with a good opera-glass, and their appearances and disappearances can be noted. The polarization of the corona can be seen well by a polarizing test which acts by extinction, as the Nicol's prism. Possibly, with a hand-spectroscope and narrow-chink, lines in the spectrum of the corona may be seen. And marine and meteorological phenomena may be noticed, such as have never yet been observed.

Viewing the general ability and intelligence of the Officers of the Peninsular and Oriental Steam Company, and the rank and education of the passengers who may probably be making the voyages, it is not too much to hope that advantage may be taken of this opportunity, such as will never again recur, to observe with care this great phenomenon.

Royal Observatory, Greenwich,
1867, *December* 7.

On the Solar Eclipse, Aug. 1868.

By G. Johnstone Stoney, M.A., F.R.S.

In May last I sent a Memoir to the Royal Society on the constitution of the atmospheres of the Sun and stars, which contained in an Appendix suggestions relative to observations of much interest which might be made during the Eclipse of August 1868, and for which there will not occur so good an opportunity for several years afterwards. An abstract of this communication has been published in the *Proceedings of the Royal Society*, and reprinted in the *Philosophical Magazine*, but the memoir and its appendix are not yet in type. As so great a delay has occurred, I fear lest the suggestions to which I have referred may not appear in time to be of use, and I therefore venture to submit them to the Royal Astronomical Society.

In the memoir it is shown that the gases which constitute the solar atmosphere range to unequal heights, and that the order in which the outer boundaries of those which are known succeed one another is probably the following:—Hydrogen extending furthest; then in order after it sodium and magnesium; calcium; chromium, manganese, iron, cobalt, and nickel; and lastly, copper, zinc, and barium. These, and whatever other gases exist in the Sun's atmosphere, intercept all light coming from beyond them of the refrangibilities which correspond to their spectral rays, and substitute for it the feebler light which emanates from their own upper strata. In this way they produce those dark lines in the spectrum which are so familiar, and the various intensities of which depend in great measure upon the different temperatures of the upper layers of the gases in which they have their origin.

Now if the Corona which is seen during a total eclipse is caused, as we must presume, by the Sun's enormous outer atmosphere projecting beyond the disk of the Moon, the light which reaches us from it is probably in part borrowed light, and in part due to the atmosphere being itself self-luminous. Borrowed light, however it may originate,* will give a spectrum resembling the Sun's, whereas any light emitted by the Solar atmosphere in virtue of its being incandescent will consist of bright rays in the same positions as some of Fraunhofer's lines. Accordingly, when examined through a spectroscope, adapted to an equatoreal telescope,† much of the light of the Corona may be found to resolve itself into a multitude of bright lines, the brightest being coincident with the faintest of Fraunhofer's lines. If this should prove to be the case, and if the observer could train himself to distinguish in the hurry and under such novel circumstance‡ the lines of the different gases, it would even be possible to ascertain how high in the Sun's atmosphere each reaches, by using a curved slit, and noting the moment at which each set of lines is obliterated by the advancing Moon. This would be a determination of exceeding interest. The observations should commence immediately after the beginning of totality and be kept up to the end of it, as it is only from situations close to the Sun's disk that the brightest lines can come.

Directly outside the photosphere there lies a stratum of the Sun's atmosphere which is still hotter than the photosphere, and on the outer boundary of this hot region there appears to be a shell of excessively faint cloud, part of which is to be seen in Mr. De La Rue's photographs of the Eclipse of 1860. It probably extends the whole way round the Sun. It is therefore very desirable that this faint shell, which seems to lie at a distance of 8 or 10 seconds of space from the edge of the Sun's disk, should be observed, both from a central station and from stations close to the northern and southern limits of totality, so as to ascertain whether, as we have reason to presume, it is continuous round the disk. For this purpose telescopes of moderate power, and any way mounted, would suffice.

It is not likely that there will be many spots, but if any should present themselves upon the edge of the disk within a week of the eclipse they should be observed for some days before and after, with a view to learning whether they are related to ascending clouds in the way pointed out in the memoir. These observations could probably be best made at Kew, but to guard against bad weather, it might be advisable to associate with Kew some other Observatory. Possibly there may be records in existence for instituting this inquiry in regard to the eclipses of 1842, 1851, or 1860. It is perhaps not impossible that the heavy mass of cloud marked $g g^1$ in Mr. De La Rue's diagram of the eclipse of 1860, may have been the source of a cyclone which occasioned the neighbouring group of spots. If so, the cloud must have afterwards drifted a good deal towards the pole (which is the direction in which the probable course of the solar trade wind would have carried it), and also come through the rotation of the Sun into a position in which it was much foreshortened.

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* Borrowed light may come either from a mist of solid or liquid particles in the Sun's atmosphere, or because some of the gases are sensibly coloured, or from irregular refractions occasioned by the troubled condition of the Sun's atmosphere; but will not in any considerable degree arise from the illumination of the Earth's atmosphere. It is from the absence of this last and chief source of borrowed light that the Corona comes into view, and observations during an eclipse are so precious.

† The equatoreal stand is not essential, as it would be enough to provide a side reflector with a slit in it, through which the rays to be observed in the spectroscope shall pass; and the rest of the image being viewed in the reflector by an assistant, he could by hand movements sufficiently direct the telescope. A telescope of considerable aperture and focal length would be best.

‡ One of the most novel of these circumstances is that the spectrum of each gas will present itself with inverted intensity, the brightest lines obtained by artificial means being in general those which are dimmest in the Corona, and *vice versâ*.

Finally, it is evident from the observations of the eclipse of 1860, that flame-like protuberances are formed of various materials. Probably they are most of them very attenuated mists of solid or liquid particles, but it is also possible that there may be some in a gaseous state. It is, in fact, shown in the abovementioned memoir that if two of the gases of the solar atmosphere are kept asunder by the temperatures which prevail in its low-lying strata, but can unite into a compound gas under the diminished temperature and pressure which prevail at greater heights, or *vice versâ*, the gas which in such cases presents itself only at great altitudes, will comport itself, in many respects, like a cloud, and in particular will become intensely heated, and emit the rays which constitute its gaseous spectrum. A similar state of things would result from such a change in the spectrum emitted by a constituent of the Sun's atmosphere, as we know from Plücker's experiments can take place in nitrogen and other gases. It is desirable, therefore, that the spectra of the protuberances should be examined, if this prove practicable, in order to determine whether they all resemble the solar spectrum, as they must if these clouds are all mists, or some of them consist of bright lines, as they will if gaseous. For such observations a telescope whose motions are under the control of an assistant looking in sideways would probably be best. I think, however, that the persons who are willing to devote themselves to such delicate observations would do well to prepare for them by staying for some time beforehand and up to the commencement of totality in the subdued light of a darkened chamber.

Shortly after the time of the solar eclipse the morning zodiacal light will be visible in great splendour to the members of the expedition, and it is very much to be desired that the opportunity should not be lost of obtaining a careful spectral examination of it by experts. This would not require any telescope;*

---

* That is, provided the collimator is sufficiently long to render the angular aperture of its lens viewed from the slit, not more than the angular breadth

but a binocular spectroscope, consisting of two similar instruments placed parallel to one another, would double the light.*

Some Remarks on the Value of the Solar Parallax, as deduced from the Parallactic Inequality in the Earth's Motion. By E. J. Stone, Esq.

In section 8 of Mr. Newcomb's "Investigation of the Distance of the Sun" will be found a discussion of the value of the Sun's mean equatoreal horizontal parallax given by the parallactic inequality in the theory of the Earth's motion. The coefficient of the parallactic inequality adopted by Mr. Newcomb is $6''\cdot520$, a value but little different from that adopted by Le Verrier in the *Annales de l'Observatoire Impérial de Paris*, Mémoires, tome iv., p. 100. The results obtained by Mons. Le Verrier were, if Π denote the mean horizontal equatoreal solar parallax, μ the mass of the Moon,

$$\mu = \frac{1}{81\cdot84} \quad \Pi = 8''95.$$

In the *Monthly Notices* for 1867, April 12, I pointed out, that a slight error had been made in the deductions of these values, and that the result should have been

$$\Pi = 8''\cdot91 \quad \mu = \frac{1}{81\cdot48}$$

Mr. Newcomb has obtained values widely different both from Mons. Le Verrier's original values and these values as corrected by me.

The values assigned by Mr. Newcomb are as follows:—

$$\Pi = 8''\cdot809 \quad \mu = \frac{1}{81\cdot08}$$

of the zodiacal light at the part of it observed. Otherwise, there will be advantage in placing a lens, which need not be achromatic, in front of each collimator.

* A similar arrangement might be used with a telescope upon all objects which are not stellar—the two spectroscopes being provided with collimators of unequal length and inclined to one another so as to be directed towards two parallel slits brought as close as possible together, and the light being diverted up one of the collimators either by total reflections, as in binocular microscopes, or by a small achromatised prism. In this way the light would be nearly doubled, an effect which could not be produced by an enlargement of the telescope. By moving the achromatised prism the image in one spectroscope could be made to shift laterally, and it is likely that the position of coincidence of the two spectra would be readily seized, even with extremely faint spectra. To secure this motion of the images with the instrument for observing the zodiacal light, the prisms of the spectroscopes might be placed a little out of the position of minimum deviation, and one of them so mounted as to admit of rotation through a small angle.

The discordances between the masses of the Moon and resulting parallaxes are so large that either Mr. Newcomb is in error or Mons. Le Verrier has made a much more important mistake than the trifling numerical one pointed out in my former paper.

I had examined Mons. Le Verrier's work by deducing a value of the Moon's mass before the publication of my short note in April, but I have now again gone through the work. The differences between the results obtained will be found to arise from two distinct causes.

1st, Le Verrier adopts

$$\text{Log}\,\frac{\Pi^3}{m''} = 8\cdot35199.$$

Newcomb adopts

$$\text{Log}\,\frac{\Pi^3}{m''} = 8\cdot35488.$$

2nd, Le Verrier finds for the relation between Π, μ and the adopted coefficient, the equation

$$\Pi = 0\cdot016620\,\text{P}\left(1 + \frac{1}{\mu}\right).$$

Newcomb,

$$\Pi = 0\cdot016461\,\text{P}\left(1 + \frac{1}{\mu}\right).$$

Neither Le Verrier nor Mr. Newcomb has given the data from which he has deduced his value of $\log\frac{\Pi^3}{m''}$.

I shall however assume the length of the invariable pendulum l beating a mean second on latitude $= \sin^{-1}\frac{1}{\sqrt{3}}$ to be

$$0^{\text{m}}\cdot992666\,\frac{434\cdot86}{433\cdot86}\,. = l\left(1 + \frac{2}{3}m\right)$$

and log (equatoreal semi-diameter of Earth in metres)

$$= 6\cdot8046271 = \log \text{R}$$

Logarithm, which must be added to log R to obtain the log $\left(\text{semi-diameter to the parallel } \sin^{-1}\frac{1}{\sqrt{3}}\right) = 9\cdot9995166.$

In these data I follow Hansen. The same data appear to me to have been adopted by Mr. Newcomb.

Then if

$$= c\left(1 + \left(\frac{1}{3} - \sin\lambda^{2}\right)\iota\right)$$

be the equation of the Earth's spheroidal surface, $f\mathrm{E}$ the Earth's mass, m the ratio of $\frac{\omega^2 c}{\text{mean gravity}}$, we have

$$f\mathrm{E} = \mathrm{G}\, c^2 \left(1 + \frac{2}{3} m\right),$$

where G is the gravity on parallel $\sin^{-1} \frac{1}{\sqrt{3}}$. Therefore

$$1 = \pi^2 \frac{l}{\mathrm{G}} = \pi^2 \frac{c^2 l}{f\mathrm{E}} \left(1 + \frac{2}{3} m\right). \qquad (1)$$

Now let T be the sidereal year expressed in mean seconds, a the length which satisfies Kepler's third law. Then

$$\mathrm{T}^2 = 4\, \pi^2 \frac{a^3}{f\mathrm{S}} \qquad (2) \quad \mathrm{S} = \left\{ \begin{array}{l} \text{Sun's mass} \\ + \text{ Earth's mass} \end{array} \right\}.$$

Now Le Verrier takes for his unit of length a, and he finds, expressed in this unit, r = mean distance of Sun from Earth $= 1{\cdot}000142 \times a$.

$$\therefore \qquad \mathrm{T}^2 = \frac{4\, \pi^2}{(1{\cdot}000142)^3} \frac{r^3}{f\mathrm{S}} \qquad (3)$$

$$\therefore \qquad \frac{\mathrm{S}}{\mathrm{E}} \cdot \frac{c^3}{r^3} = \frac{4}{\mathrm{T}^2} \cdot \frac{1}{(1{\cdot}000142)^3} \frac{c}{l\left(1 + \frac{2}{3} m\right)}$$

Now $c = \mathrm{R}\, p$; where $\log p = 9{\cdot}9995166$.

$$\therefore \qquad \frac{\mathrm{S}}{\mathrm{E}} \cdot \frac{\mathrm{R}^3}{r^3} = \frac{4}{\mathrm{T}^2} \cdot \frac{\mathrm{R}}{l} \quad \frac{1}{(1{\cdot}000142)^3 p^3 \left(1 + \frac{2}{3} m\right)}$$

$$\frac{\mathrm{S}}{\mathrm{E}} \cdot \Pi^3 = \frac{4}{\mathrm{T}^2} \cdot \frac{\mathrm{R}}{l \sin^3 1''} \cdot \frac{1}{(1{\cdot}000142)^3 p^2 \left(1 + \frac{2}{3} m\right)}$$

$$\mathrm{Log}\, \frac{\Pi^3}{m''} = 8{\cdot}35475$$

Agreeing closely with Mr. Newcomb's value.

From the theory of the motion of the Earth about its centre of gravity we have the following formula:—*Serret, Annales de l'Observatoire de Paris,* tome v.

$$\text{(A)} \qquad \iota = \frac{\text{Mass of Moon}}{\text{Mass of Sun}} \left(\frac{\text{Mean Dist. of Sun}}{\text{Mean Dist. of Moon}}\right)^3$$

$$\text{(1)} \qquad \mathrm{N} = [9{\cdot}38725]\ \kappa\,\iota$$

$$\text{(2)} \qquad \mathrm{P} = [9{\cdot}96272]\ \kappa + [9{\cdot}95922]\ \kappa\,\iota$$

$$\mathrm{N} = 9''{\cdot}223 \qquad \mathrm{P} = 50''{\cdot}378$$

I adopt the same values of the constants of nutation and luni-solar precession as Mr. Newcomb.

Then

$$\iota = \mu\ \frac{\mathrm{E}}{\mathrm{S}} \cdot \left(\frac{\frac{\mathrm{R}}{r_1}}{\frac{\mathrm{R}}{r}}\right)^3$$

$$\iota = \mu\ \frac{\mathrm{E}}{\mathrm{S}} \cdot \frac{(\mathrm{B}\ .\ \sin 1'')^3}{\Pi^3\ .\ (\sin 1'')^3} = \mu \frac{\mathrm{E}}{\mathrm{S}}\ \frac{\mathrm{B}^3}{\Pi^3}$$

where B is the *constant* of lunar parallax.

$$\therefore \qquad \iota = \mu\ \frac{\mathrm{B}^3}{\frac{\Pi^3}{m''}}$$

From (1) and (2) we find

$$\begin{aligned} &\text{Log}\ \kappa\,\iota &&= 1{\cdot}57762 \\ &\text{Log}\ \kappa &&= 1{\cdot}24018 \\ &\text{Log}\ \iota &&= 0{\cdot}33744 \\ \text{and}\quad &\mathrm{B} &&= 3422''{\cdot}707 \end{aligned}$$

These data and the value of log $\frac{\Pi^3}{m''}$, found in the present paper give $\mu = \frac{1}{81{\cdot}46}$. This value agrees closely with Le Verrier's value.

The expression for the lunar inequality in longitude is

$$\delta l = -\ \frac{m'}{m + m'}\ \frac{r'}{r}\ \cos s' \sin (l' - l)$$

where m and m' are the masses of the Earth and Moon respectively, r, r', the distances of the Sun and Moon from the Earth; s' the Moon's latitude; l', l, the true longitudes of the Moon and Earth. I shall assume that for r' the true value has been used by Le Verrier. Then, taking constant of lunar parallax $= 3422''{\cdot}7$, and denoting $\frac{m'}{m}$ by μ, the solar parallax by Π, I find

$$\Pi = 0{\cdot}016620\ \mathrm{P}\left(1 + \frac{1}{\mu}\right)$$

a result agreeing with Le Verrier.

If we adopt Le Verrier's coefficient 6″·50, we find

$$\Pi = 8''\cdot 91$$

I have not incorporated Mr. Newcomb's results with those of Le Verrier's, because Mr. Newcomb has employed the mean longitudes instead of the true. Taking Mr. Newcomb's results separately, we find for the coefficient the numerical value $= 6''\cdot 548$. We must now use Mr. Newcomb's equation of condition between Π and P, but I use my own value of $\mu = \frac{1}{81\cdot 46}$. I thus find

$$\Pi = 8''\cdot 89$$

a result almost identical with that obtained from Le Verrier's coefficient.

The values thus obtained depend, as I stated in my Note of April last, almost entirely on the adopted value of the Moon's mass. The deduction of the value of this quantity, to the required degree of accuracy, from the theory of Precession and Nutation. is a point of considerable difficulty. Mr. Newcomb has applied some corrections for terms of the third order to Serret's results for the equation determining the constant of Nutation, but has used the Precession equation unaltered. I have used Serret's results, neglecting all terms of the third order. If we employed Mr. Newcomb's value of the Moon's mass, we should find

$$\Pi = 8''\cdot 87.$$

On Bessel's Mean Refractions. By E. J. Stone.

The refraction-corrections, employed in the reduction of the Greenwich Observations, since 1857, have been computed in the following manner:—

To 82° Z. D. the refractions are those of Bessel's *Tabulæ Regiomontanæ;* from 82° to 85° Z. D. those of the *Tabulæ Regiomontanæ,* with the logarithms of mean refraction diminished by 0·00100; and, finally, from 85° Z. D., the refractions are those of Bessel's *Fundamenta* diminished in the proportion of 1:0·99848. The abrupt changes in passing through 82° and 85° Z. D., can scarcely be considered satisfactory. From the existence of several small, but systematic discordances, I have for some time been convinced, that our refraction-corrections for zenith distances less than 85° are too great. The object of the present paper is to put this in evidence, and to endeavour to determine some more satisfactory method of computing the refraction-corrections.

I have, in the first place, compared the observations of stars above and below the pole, made at Greenwich from the years 1857 to 1865. Let c be the adopted co-latitude; $c + \frac{x}{2}$ the true co-latitude. R, R_1, the tabular refractions below and above the pole. $R(1 - y)$, $R_1(1 - y)$, the true refractions. Δs, Δd, the mean N.P.D. for the beginning of the year, derived from the observations below and above pole, respectively. a, b, the number of observations below and above pole. We then have an equation of condition

$$x + y(R \pm R_1) = \Delta s - \Delta d,$$

With a (probable error)² proportional to $\left(\frac{1}{a} + \frac{1}{b}\right)$.

From the observations of the different years I have found for each star the value of $\Delta s - \Delta d$ and have then weighted the several results, roughly, in proportion to $\frac{ab}{a+b}$ or w, and thus found mean values of $\Delta s - \Delta d$ with a weight $S(w)$. The factors for y are then computed for the star's zenith distance, with an assumed barometer reading of 30 in., and thermometer 50°. The results of each year have been thus separately treated, in order that the observations, above and below pole, might always have been corrected with the same empirical law of R — D, or law of discordance between reflexion and direct observations. A few observations are, of course, lost by this method of proceeding. I have thought this of little consequence compared with the probable diminution of systematic error. The reflexion observations having been used in determining the co-efficients in the assumed law of R — D have not been further employed in the present paper.

I have next divided the observations into five groups.

1st.	N.P.D.	0°	to 15°
2nd.		15°	to 30°
3rd.		30°	to 37° 40′
4th.		37° 40′	to 43°
5th.		43°	to 46° 29′

In the first group, *Polaris* is observed so frequently, that, if we weighted the observations merely in accordance with the number of observations, the co-latitudes would be made to depend almost entirely upon the observations of *Polaris*, and would thus be affected with any outstanding uncorrected error in the divisions of the circle employed in the observations of *Polaris* and *Polaris* S.P.

It became necessary, therefore, to fix upon some maximum for the weight, calculated in the ordinary way, from the number of observations. Let e be the probable error of an observation of a star in N.P.D., determined in the ordinary way, by the discordances of the individual observations in a large group from the mean. ι the probable error of the outstanding division errors of the parts of the circle employed in the observations. Then if a, b, a_1, b_1, are the numbers of observations below and above pole of two different stars, and

$$w = \frac{a\,b}{a+b} \qquad\qquad w_1 = \frac{a_1\,b_1}{a_1+b_1}.$$

and W and W_1 are the true weights of the resulting co-latitudes. We have

$$\frac{1}{W} = \left(\frac{1}{a} + \frac{1}{b}\right) e^2 + 2\,\iota^2 = \frac{e^2}{w} + 2\,\iota^2,$$

$$\frac{1}{W_1} = \left(\frac{1}{a_1} + \frac{1}{b_1}\right) e^2 + 2\,\iota^2 = \frac{e^2}{w_1} + 2\,\iota^2,$$

$$\frac{W_1}{W} = \frac{1 + \frac{e^2}{\iota^2}\cdot\frac{1}{2\,w}}{1 + \frac{e^2}{\iota^2}\cdot\frac{1}{2\,w_1}}.$$

For *Polaris* and *Polaris* S.P. we have $e = 0''\cdot6$, and ι very nearly $0''\cdot2$. If, therefore, we put w indefinitely great

$$\frac{W_1}{W} = \frac{1}{1 + \frac{4\cdot5}{w_1}}.$$

and for $w_1 = 20$,

$$\frac{W_1}{W} = \frac{5}{6} \text{ very nearly.}$$

After, therefore, the theoretical weight 20 is reached, very little greater accuracy can be expected, however much the number of observations may be increased.

I have employed 20 as the maximum weight to be assigned to the co-latitude determined from observations of any one star.

The discordances for the five groups are

(1)	+ 0''·240	weight	130
(2)	+ 0·196		88
(3)	+ 0·570		31
(4)	+ 1·054		54
(5)	+ 2·190		28

The equations connecting these discordances and the corrections for co-latitude and mean refraction are

$$
\begin{array}{lrrcr}
(6) & 11\,x & +\,1034\,y & = & +\,2''\!\cdot64 \\
(7) & 9\,x & +\,1197\,y & = & +\,1\cdot76 \\
(8) & 6\,x & +\,1272\,y & = & +\,3\cdot42 \\
(9) & 7\,x & +\,2030\,y & = & +\,7\cdot39 \\
(10) & 5\,x & +\,2350\,y & = & +\,10\cdot95
\end{array}
$$

The equations have been multiplied by numbers to make the probable errors of the second members nearly equal. Reducing these equations by the method of least squares, we find the following equations:

$$
\begin{array}{rcrcr}
312\,x & + & 56465\,y & = & 171''\!\cdot88 \\
56465\,x & + & 137633349\,y & = & 49920\cdot92
\end{array}
$$

From which we have

$$x = -\,0''\!\cdot410 \qquad\qquad y = 0\cdot00531$$

The discordances (1), (2), (3), (4), and (5), are reduced as follows:—

1	+ 0″·24	″·15
2	+ 0·20	− 0·10
3	+ 0·57	− 0·14
4	+ 1·05	− 0·08
5	+ 2·19	+ 0·10

The discordances are now reduced to quantities quite within outstanding division errors even over a group.

The result gives for Greenwich

co-latitude 38° 31′ 21″·61.

The value of y indicates that the mean refractions as given by Bessel's *Tabulæ Regiomontanæ* at barometer 30 in., and thermometer 50°, require to be diminished in the proportion of 0·99469 : 1. I have here only considered the case of Z. D. from 0° to 85°.

Now in the *Tabulæ Regiomontanæ* the refractions to 85° Z. D. are those of the *Fundamenta* increased in the proportion of 1·003282 to 1.

If, therefore, we adopted the refractions of Bessel's *Fundamenta* we should only require to diminish the refractions in the proportion of 0·99797 to 1.

For zenith distances below 85° Z. D. the Greenwich Observations are at present reduced with the refractions of the *Fundamenta* diminished in the proportion of 0·99848 : 1.

The refractions thus reduced appear to represent the observations as closely as can be well expected for such considerable zenith distances.

If, therefore, we adopted for Greenwich the refractions of the *Fundamenta*, with the mean refractions diminished in the proportion of

$$0\cdot99797 : 1,$$

we should have all our refractions computed from one set of tables, and representing the observations (in mean results) within, or at least very nearly within, errors of observation.

The publication of the Melbourne Observations for 1863, 1864, and 1865, furnishes a large number of observations in N.P.D. comparable with corresponding observations at Greenwich. I have, therefore, availed myself of the Melbourne Observations to test the accuracy of the proposed diminution of the Greenwich tabular refractions. It has, however, been first necessary to discuss the Melbourne Observations above and below pole in the same manner as the Greenwich Observations, in order to obtain the Melbourne colatitude. The Melbourne refractions have been computed from the *Tabulæ Regiomontanæ*. Proceeding exactly in the same way as for the Greenwich Observations, I have divided the results into five groups.

				Direct — S.P.	Weight.
(1)	N.P.D.	147°	to 150°	+2″·480	11
(2)		150	155	+1·585	8
(3)		155	160	+0·726	8
(4)		160	170	+0·738	26
(5)		170	Pole	+1·007	122

From these groups I have formed the following five equations with second members nearly equally probable:—

$$3x + 1446y = +7''\cdot440 \qquad (6)$$

$$3x + 1020y = +4\cdot755 \qquad (7)$$

$$3x + 705y = +2\cdot178 \qquad (8)$$

$$5x + 870y = +3\cdot690 \qquad (9)$$

$$11x + 1694y = +11\cdot077 \qquad (10)$$

Solving these equations by the method of least squares, I find

$$x = +0''\cdot298 \quad . \quad y = 0\cdot00372$$

The discordances (1), (2), (3), (4), (5), are reduced as follows:—

1	+2″·48	to	+0″·39
2	+1·59		+0·03
3	+0·73		−0·44
4	+0·74		−0·20
5	+1·01		+0·23

There are many very abrupt changes in the corrections applied for division error to the Melbourne Circle, and some considerable uncertainty must exist from this cause in the results. I believe the above discordances are not much greater than may be expected.

Finally, I have compared the Greenwich and Melbourne Observations in N.P.D. I have employed for this purpose the results of the Greenwich seven-year Catalogue, and have brought up all the observations to the year 1864 for comparison with the Melbourne results. I have then divided the corresponding observations into eleven groups.

			Green. N.P.D. — Melb. N.P.D.	Weight.
1	N.P.D. 45° 12′		+3″·04	9
2	50° to	55°	+1·71	21
3	55	60	+0·87	25
4	60	70	+1·35	100
5	70	80	+1·52	121
6	80	90	+0·99	138
7	90	100	+0·62	82
8	100	110	+0·86	78
9	110	115	+0·83	53
10	115	120	+0·72	56
11	120°		+1·30	16

Assuming that the true refraction

$$\text{For Greenwich} = \text{Tab.}\,(1 - x)$$
$$\text{For Melbourne} = \text{Tab.}\,(1 - y)$$

and that the relative correction for errors in latitude is δc, we have the following equations with nearly equally probable second members:—

1 $21x + 1245y = +9''{\cdot}12 + 3\,\delta c$
2 $65x + 1180y = +8{\cdot}55 + 5\,\delta c$
3 $105x + 785y = +4{\cdot}35 + 5\,\delta c$
4 $270x + 1200y = +13{\cdot}50 + 10\,\delta c$
5 $484x + 825y = +16{\cdot}72 + 11\,\delta c$
6 $720x + 660y = +11{\cdot}88 + 12\,\delta c$
7 $783x + 342y = +5{\cdot}58 + 9\,\delta c$
8 $1260x + 207y = +7{\cdot}74 + 9\,\delta c$
9 $1428x + 112y = +5{\cdot}81 + 7\,\delta c$
10 $1995x + 77y = +5{\cdot}04 + 7\,\delta c$
11 $1520x + 32y = +5{\cdot}20 + 4\,\delta c$

From which we obtain the following equations for the determination of x and y:—

$$11371545\,x + 2274567\,y = 61872{\cdot}12 + 66005\,\delta c$$
$$2274567\,x + 6294185\,y = 67408{\cdot}69 + 48947\,\delta c$$

$$x = +0{\cdot}003556 + 0{\cdot}00458\,\delta c$$
$$y = +0{\cdot}009424 + 0{\cdot}00612\,\delta c$$

or putting $\delta c = -\,0{\cdot}056$,

$$x = +0{\cdot}0033$$
$$y = +0{\cdot}0091$$

The errors Green. N.P.D. — Melb. N.P.D. are then reduced as follows:—

				Weight.
(1)	+3″·04	to	−0″·76	9
(2)	+1·71		−0·48	21
(3)	+0·87		−0·63	25
(4)	+1·35		+0·16	100
(5)	+1·52		+0·69	121
(6)	+0·99		+0·29	138
(7)	+0·62		−0·02	82
(8)	+0·86		+0·18	78
(9)	+0·83		0·00	53
(10)	+0·72		−0·33	56
(11)	+1·30		−0·04	16

The first residual (1) depends upon the observations of only one star. If we rejected the equation arising from (1), the values of x and y would not be greatly modified. The discordances are here larger than could be wished, but, except for the first, I doubt whether they are greatly in excess of uncertainties connected with division errors.

The value of x shows that the refractions of Bessel's *Tabulæ Regiomontanæ* require to be diminished considerably in order to represent the Greenwich Observations. So far as the comparison with the Melbourne Observations is concerned, the refractions of the *Fundamenta* would almost do for Greenwich without any correction. I believe, however, that the result obtained from the Greenwich Observations, above and below pole, is entitled to most weight. The correction thus deduced for the Melbourne refractions is exceedingly great, viz. $y = 0{\cdot}00914$, whilst, from a comparison of the Melbourne Observations above and below pole, I obtained only a correction of

$$y = 0{\cdot}00372.$$

The discordance between these results is so great, that if we introduced one of the values into the equations from which the other has been deduced, the residual errors would be much greater than any existing uncertainties connected either with observations or outstanding errors of division. At least this is my own opinion on the point. I am, therefore, inclined to look upon the difference as real, not perhaps to the full amount of the discordance, but to a considerable amount, and to attribute it to a real difference in mean refraction towards the south and north at Melbourne, the refractions towards the south being greater because of the moisture present in the air, the refractions towards the north being considerably less because the chief effective strata of air have been to a considerable extent deprived of moisture.

14th November, Meteor Epoch 1867. By E. J. Lowe, Esq.

Nov. 12. Foggy and densely overcast all evening and night.

Nov. 13. Foggy and overcast, with E.N.E. wind, till $7^h 40^m$ P.M., when the sky suddenly became cloudless and the wind changed to S.E., from this time till $9^h 10^m$ P.M. no clouds and no meteors. At $9^h 10^m$ P.M. few cumuli; $9^h 30^m$ P.M. overcast with cumuli in S. current.

Nov. 14. $1^h 10^m$ A.M. again clear, except few high thin cirri. Wind S. Lunar halo faint, and a yellow glare on N. horizon extending to altitude 15°.

$1^h 27^m 30^s$ A.M. a colourless meteor, = ∗ 2 mag., shot rapidly from near λ to β *Ursæ Majoris.*

2 A.M. high thin cumuli in S., current moving rapidly.

2 A.M. till 3 A.M. ibid. No meteors.

$3^h 10^m$ A.M. sky covered with rapidly-flying thin cumuli in S.E. current, above which others in S. current. Slight breeze and no fog.

$3^h 55^m$ A.M. overcast, Moon's place visible.

$5^h 15^m$ A.M. ibid., wind N.E., clouds rapid from S.E.

$5^h 50^m$ A.M. quite overcast, hazy wind N.E.; sky lighter to E. of zenith than elsewhere.

$7^h 40^m$ A.M. ibid., fog coming on.

From 9 A.M. fog with incessant rain till 7 P.M., then fair; fog cleared off, but overcast.

15th. Overcast.

Highfield House,
1867, *Nov.* 19.

The Meteors of November 13–14, 1867, *observed at Bloomington, Indiana.* By Prof. Daniel Kirkwood, L.L.D.

During the night of November 13th, Prof T. A. Wylie, D.D., and myself, assisted by several students, kept watch for meteors from $9^h\ 15^m$ P.M. to $5^h\ 15^m$ A.M., at the Indiana University, Bloomington, Indiana. The night was very unfavourable for observations, the sky being obscured by so dense a haze that scarcely any fixed stars, except those of the first magnitude, were at all visible. Hence none but the largest meteors and such as appeared near the zenith could be detected. The results obtained were as follows:—

	h m		h m		
November 13th, from	9 15	to	12 0*	1	meteor.
14th,	0 0		3 15	75	meteors.
	3 15		4 15	351	,,
	4 15		5 15	98	,,
			Total	525	meteors.

It will be noticed that 351, or two-thirds of the whole number seen in eight hours, were observed between $3^h\ 15^m$ and $4^h\ 15^m$. The maximum occurred about $3^h\ 45^m$, when the rate was twelve per minute. All the meteors, with one or two exceptions, were "conformable." Two or three were sometimes seen simultaneously, and a tendency to appear in clusters was distinctly noticed. A very remarkable meteor was observed in *Leo*, a little above the *Sickle*, about $3^h\ 40^m$. It was *stationary*, and continued visible between two or three seconds. It was at first small, but increased rapidly in magnitude until, just before extinction, it surpassed *Regulus*, the only star in the *Sickle* then visible through the haze. This meteor was undoubtedly near the radiant. On account, however, of the cloudy state of the atmosphere no effort was made to locate the common point of divergence.

Bloomington, Indiana,
November 14th, 1867.

An Attempt to facilitate the Prediction of Occultations and Eclipses, and the Approximate Reduction of the observed Phenomenon. By F. C. Penrose, Esq. (Abstract.)

As regards occultations; an occultation (disappearance or reappearance) takes place when the surface of the Earth (considered in the memoir as a spheroid of revolution) intersects the cylinder generated by the rays of light proceeding from the star and touching the Moon's circumference.

---

* Cincinnati time.

The author submits two methods of solution, part of the process being in each of them geometrical, or, more properly speaking, graphical, conducted by means of an orthographic projection of the occurrence, as seen from the direction of the star: he thinks that the methods are capable of sufficient accuracy for many purposes, and have the advantage that the object of every step is readily seen by the operator, and also of being more expeditious than the methods depending solely on calculation.

The first method, worked with the help of Chart No. I., is intended for prediction only, and may be expected to occupy a few minutes only in the operation, and to furnish an approximate result with an error not exceeding two minutes of time in ordinary cases.

The second method worked by Chart No. II., and which depends to a less degree on geometrical work, ought to give a result true within two minutes of longitude, or eight seconds, or say half a second of the Moon's R.A., except in cases where the star impinges on the Moon's limb at an acute angle, or, in other words, when the observer is at a considerable distance from the central line of occultation, when the error will probably be greater; and such cases should not be relied upon for the determination of longitude unless both the disappearance and reappearance can be observed.

The representation of an eclipse, treated in an analogous way to the occultation, is that of a *perspective* projection on a plane perpendicular to the line of conjunction, and with the Sun at conjunction as the point of view, and at the Moon's distance from the Sun, instead of the *orthographic* projection which represented the occultation.

On the Influence of Aperture in Diminishing the Intensity of the Colour of Stars. By John Browning, Esq., F.R.A.S.

At the last Meeting of the Society some remarks were made on the subject of the amount of colour visible on the Moon during the late lunar eclipse.

I had previously stated that I had failed to detect either the coppery or the blue tints generally seen during the occurrence of this phenomenon. As my observation did not agree with those of several well-known observers, I have given the matter some attention, and endeavoured to ascertain from what cause the discrepancy proceeded.

Mr. Slack suggested that probably my having used a telescope of larger diameter than those employed by most of the observers would prove the explanation desired, and since then I have heard that our able Secretary, Mr. Huggins, is of the same opinion. The result of my inquiries completely confirms this suggestion. I find that while most observers who use telescopes of only three or four inches aperture speak of the colour as being less than usual, yet very noticeable, observers who use telescopes of seven or eight inches aperture saw very little colour. Neither Mr. Barnes nor myself, observing with a 10¼-aperture, nor Mr. With or his nephew, employing a 12¼-inch silvered-glass speculum, could detect any colour at all.

It is true that I failed equally in detecting colour with a 4-inch object-glass, but I account for this by supposing that the sensitiveness of my eye to faint-coloured light had been injured by the glare of the Moon in the large aperture. Experimenting in connexion with this subject, I have noticed that the chocolate colour of the so-called belts of *Jupiter* is much more perceptible with 6-inches aperture than with 12-inches. Again, a small star in the cluster in *Perseus* appears of an indigo-blue with 8½-inches, prussian-blue with 10¼-inches, and royal-blue with 12¼-inches of aperture. It follows from this that colours estimated by comparison with the ingenious chromatic scale of Admiral Smyth, in which each colour is represented of four different degrees of intensity, will not possess any relative value unless taken in connexion with the aperture employed when the colour was estimated. Were due allowance made for this disturbing influence of variation of aperture, I think many discrepancies between the colours attributed to double stars by different observers might probably be reconciled.

Note.—An enlarged diagram of Smyth's chromatic scale, and another showing the apparent difference in the colour of a star when seen with apertures of 4 inches and 12 inches, was exhibited and described at the time the paper was read.

Minor Planet (93).

The following elements, calculated by Herr Lehrmann from observations of Aug. 25, Oct. 2, and Nov. 4, are given *Astron. Nach.* No. 1669:—

Epoch, 1867, Oct. 2·0, Berlin M.T.

$$
\begin{array}{l}
M = 66^{\circ}\ 47'\ 48''{\cdot}8 \\
\left.\begin{array}{l}
\varpi = 276\ 39\ 54{\cdot}8 \\
\Omega = 5\ \ 2\ 28{\cdot}0 \\
i = 8\ 35\ 34{\cdot}9
\end{array}\right\}\text{. Mean Equinox, 1867·0.} \\
\phi = 7\ 39\ 29{\cdot}5 \\
\mu = 776''{\cdot}43667 \\
\log a = 0{\cdot}439934
\end{array}
$$

ERRATUM IN LAST NOTICE.

Page 1, in the list of persons elected, *for* Alnwrah Road, *read* Almorah Road.

CONTENTS.

Page

Fellows elected 17

Note on the Total Solar Eclipse of 1868, August 17–18, by Mr. Airy ib.

On the Solar Eclipse, Aug. 1868, by Mr. Johnstone Stoney 18

Some remarks on the Value of the Solar Parallax, as deduced from the Parallactic Inequality in the Earth's Motion, by Mr. Stone ... 21

On Bessel's Mean Refractions, by Mr. Stone 25

14th November, Meteor Epoch 1867, by Mr. Lowe 32

The Meteors of November 13–14th, 1867, observed at Bloomington, Indiana, by Prof. Kirkwood 33

An attempt to facilitate the prediction of Occultations and Eclipses, and the approximate Reduction of the observed Phenomenon, by Mr. Penrose (Abstract) ... ... ib.

On the Influence of Aperture in Diminishing the Intensity of the Colour of Stars, by Mr. Browning 34

Minor Planet (93) 35

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *January* 10, 1868. No. 3.

Rev. Charles Pritchard, M.A., F.R.S., in the Chair.

George Parker Bidder, Esq., Paper Buildings, Temple;
Capt. Drayson, R.A., Military Academy, Woolwich;
R. P. Greg, Esq., Prestwich, Manchester;
R. J. Lecky, Esq., Stock Orchard Villas, Caledonian Road;
John Sorley, Esq., LL.D., Principal of the College, Birkenhead;
Thos. Hunter Maule, Esq., LL.D., Vice-Principal of Birkenhead College; and
The Rev. Wm. Owen Williams, Pwleheli, Carnarvonshire.

were balloted for and duly elected Fellows of the Society.

Rotation of Mars. By Richard A. Proctor, B.A.

A series of clearly marked views of *Mars*, taken by Mr. Browning in January and February, 1867, afforded me the opportunity of estimating the rotation of *Mars* by means of an interval of nearly 201 years. In doing this I detected some slight errors in my former calculation. First, the construction of a chart of the orbits of the four inner planets enabled me to form a more accurate estimate of the difference in the geocentric longitude of *Mars* on April 24th, 1856, and on November 26th, 1864, as compared with his geocentric longitude on March 13th, 1666; secondly, the preparation of a chart of *Mars* suggested alterations in the corrections for phase; and, lastly, I found that

I had unaccountably dropped a day in taking the interval of 198 years. The effect of the last error is less important than might be supposed at first sight, since on adding twenty-four hours to the interval, we have to add one rotation of *Mars* to the number taking place in the interval, and it is the difference between one rotation of *Mars* and twenty-four hours (*i.e.* about $37\frac{1}{3}$ minutes only) which has to be distributed amongst upwards of 70,000 rotations.

I now present in a table the results of the calculation of three long periods, viz. from March 12th, 1666, $12^h\ 20^m$ (astronomical time and New Style) to

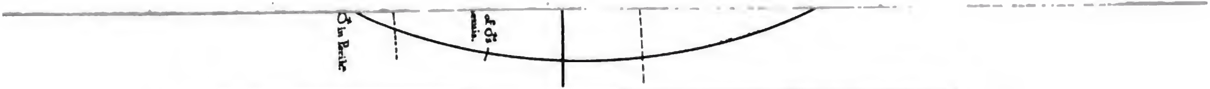
April 24th, 1856 .. .. (i)
Nov. 26th, 1864 .. .. (ii)
Feb. 23rd, 1867 .. .. (iii)

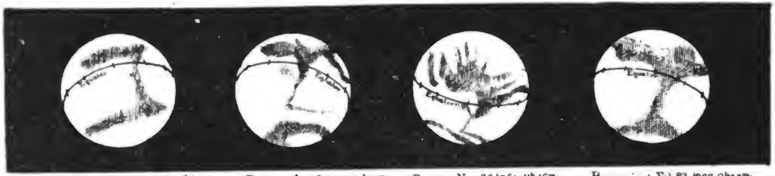
Int.	Interval in secs.	Cor. for Geoc. Long.	Cor. for Phase.	Corrected Int. in seconds.	No. of Rotations.	Resulting Rotation Period.
(i)	5999524200	0°	− 12°	5999521246	67682	88642·737
(ii)	6270650760	− 248	0	6270589696	70740	88642·734
(iii)	6341394300	− 273	+ 3	6341326590	71538	88642·734

Here the results have been brought into close agreement by selecting suitable values for the phase-corrections. That these values are not far from the truth will be seen by the accompanying tracings of the views in question (see Plate); the arc from cross-line to cross-line along the equator of *Mars* being, of course, 30°.

The corrections for geocentric longitude may be depended upon as being within 1° of the truth. In the accompanying copy of my plate of the orbits of *Mars*, the Earth, *Mercury*, and *Venus*, the positions of *Mars* and the Earth at the several epochs are indicated and connected by straight lines. In determining the approximate position of the Earth at any date several circumstances have to be considered. Thus take the opposition of *Mars* in March, 1666. I find that this took place at midnight (nearly) on March 18th. But it will be seen that the opposition line is placed about one quarter of a degree in advance of the position given to the Earth on March 21. The explanation of this will illustrate the process applied to each epoch:—

My chart shows the position of the Earth from day to day on the supposition that at noon on the 21st December the Earth is at the winter solstice. Now, nearly enough for our purpose, this was the case in leap-year in the beginning of the seventeenth century. But the Earth was about 45′ in advance of the winter solstice at noon on December 21st in leap-years *at the end* of the seventeenth century,—therefore, in 1664, about 30′ in advance. Again, in each common year the Earth loses 15′, so that in 1666 there was at any hour of any day, after February 28, a loss of





Hooke, Mar. 12, 1666, 12h. 20m.   Dawes, Apr. 24, 1856, 10h. 30m.   Dawes, Nov 26, 1864, 11h. 46m.   Browning, Feb 23, 1867, 6h. 25m.

about 30′ from the position held by the Earth at the same day and hour in 1664. Therefore the position of the Earth at midnight, March 18th, 1666, was about that which would correspond to that date as the chart stands; that is, about two days and a half's motion (or nearly 2½°) behind the point marked March 21st. But owing to the precession of the equinoxes the lines ♋ ♑, and ♎ ♈ in my chart must be shifted about 2¾° forwards around their point of intersection to indicate the position they had in 1666. The difference ¼° indicates the amount by which the opposition-line in question is in advance of the position given to the Earth on March 21st in my chart.

The close agreement between the results obtained,—and that without any noteworthy *forcing* of the correction for phase, ***the only doubtful point in the whole question***, induces me to look on the value

$$88642\cdot735\text{ sec. or }24^{h}\ 37^{m}\ 22\cdot735^{s}.$$

as very near the true value of *Mars*' rotation period.

Inductive Proof of the Moon's Insolation.
By J. Park Harrison, M.A.

1. On the assumption that the Moon's substance has a capacity for heat, the mean maximum state of insolation of any hemisphere would evidently be attained at the period of the lunation when the largest surface has been continuously exposed to the Sun *for the longest duration of time.* This occurs at the third or last quarter, when the half-moon then illuminated has been subjected to the solar radiation for a mean period of 265·5 hours $\left(\frac{177\text{ hrs.} + 354\text{ hrs.}}{2} = 265\cdot5\text{ hrs.}\right)$, and the remaining half, now in shade, has very recently received the Sun's rays for a period of equal duration.

The epochs of maximum and minimum heat are clearly shown on a horizontal section of the Moon in the diagram (fig. 1), where the light and dark crescents represent her state of insolation in proportion to the number of days during which the Moon's surface has been exposed to or withdrawn from the Sun.*

2. Now the heat which is acquired by the Moon,† and radiated to the Earth, is entirely dark heat; and this, as Prof. Tyndall has pointed out, "would be almost wholly absorbed by our

---

* The plus signs before the figures in this diagram (+ 1 to + 15) indicate the number of days of sunshine. The minus signs indicate the number of days of shade. In fig. 2 the dark tint A represents heat; the lighter tint B, cold.

† The German physicist Herr Althaus has estimated the heat of the Moon on the 22nd day of the lunation by an elaborate process at several hundred degrees of Fahrenheit. *Pogg. Ann.* 90, p. 551.

atmospheric vapour."* It would consequently tend to raise the temperature of the air above the clouds, and cause increased evaporation from their surface. Cloud would therefore be diminished in density and raised to a higher elevation, and under favourable circumstances it would be dispersed;† in either of which events a sensible fall would necessarily be caused in the temperature of the air near the ground, owing to increased radiation of terrestrial heat to the sky. And precisely opposite results would occur at the period of minimum heat in the Moon.

If our ordinary thermometers, then, give no indication of any changes of temperature at these seasons, it would show either that the Moon is *not* heated by the Sun, or that her state of insolation is insufficient to produce the physical effects which would otherwise have followed.

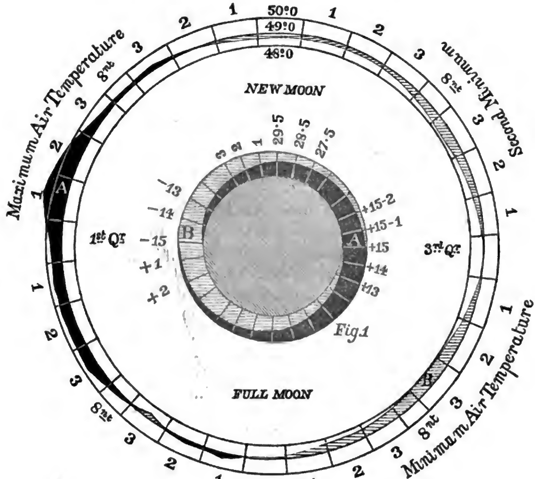


Fig.2

3. The daily mean temperatures, however, at the Observatories of Oxford, Berlin, and Greenwich, when arranged in tables according to the age of the Moon, show conclusively that the temperature of the air near the surface of the ground is very sensibly affected; the maximum mean temperature occurring on

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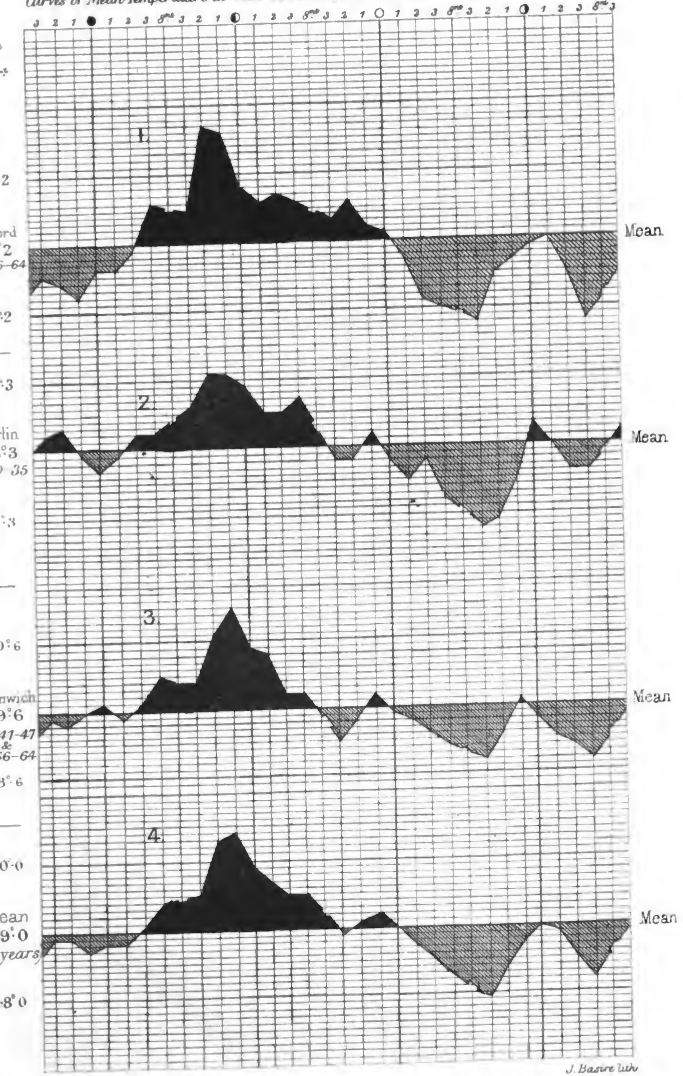
* *Heat*, &c., p. 147. See also Herschel's *Outlines of Astronomy*, 432, p. 261.

† Herschel's *Lectures on Scientific Subjects*, 1866, p. 149.

Curves of Mean Temperature at Oxford, Berlin & Greenwich according to the age of the Moon.



Note, The number of Octant days [☾] is about half of the othe

the average, at each of the three stations, upon the 6th and 7th day of the lunation, when the Moon's crust turned towards the Earth is coldest; and the minimum mean temperature some time after full Moon, when the same crust has been exposed for several days to intense radiation from the Sun.*

This will be seen in the diagram (fig. 2), where a curve of the mean temperatures for each day of the lunation, described about the section of the Moon already referred to, shows the contemporaneous conditions of air-temperature and lunar insolation. The curve itself is derived from the mean results at the three Observatories.

In the curves formed from these means, the dark tint indicates a mean temperature above the average, whilst the lighter tint indicates a mean temperature below the average. It will not escape notice that they coincide in a very remarkable manner (see Plate of Curves).

The Berlin mean temperatures, which were tabulated by Dr. Mädler thirty years ago, were derived from observations taken at 5 A.M and 2 P.M. from 1820 to 1835. The difference between the maximum at first quarter and the minimum near the last quarter is 2°·3 Fahr.†

At Oxford the daily means were obtained from twelve readings of traces of the self-registering Thermograph, with a few interpolations. The difference between the maximum and minimum mean temperatures is 2°·8 Fahr.

The Greenwich means were derived from the 2-hourly observations of 1841–47; excepting the means on Sundays and holidays, which are simply arithmetical means of the self-registering maximum and minimum thermometer. From 1856 to 1864 inclusive they were derived from the ordinary daily observations corrected by a small quantity and checked by an examination of the photographic curves. The difference between the maximum and minimum results is 2°·3 Fahr.

The mean difference in the value of the results at the three Observatories is 2°·5 Fahr.

4. It will be noticed in the diagram (fig. 2) and also in each curve (see Plate), that, whilst there is but one period of maximum air temperature, two minima occur at nearly equal distances on either side of the Moon's third quarter. They are separated by a marked rise in the curve at the time the greatest heat is assumed to be attained by the Moon, and consequently the lowest mean temperature of the air might have been looked for.

This apparent exception to the physical law above indicated seems to afford additional proof that the general results are due to the causes to which they have been assigned—*fresh cloud having been found to arise a day or two before the third quarter*[*] to supply, as it would seem, the increased demand[†] for vapour at that period. And the moment when this periodic cloud is dispersed or raised by the agency of the Moon's heat is signalized by the rapid fall in temperature which occurs immediately afterwards. Possibly, however, some part of the lunar radiant heat may reach the surface of the Earth at the time of the Moon's maximum insolation, and so assist in raising the temperature of the air, and in producing increased evaporation.[‡]

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* For method of tabulation see *Proceedings of the Royal Society*, May 1865, p. 224.

† On ascertaining the occurrence of the maximum air-temperature on the 6th day after new Moon, Dr. Mädler seems to have put the figures aside for confirmation. He has not since then, that I am aware of, made any use of them; or suggested any explanation of the results.—See *Der Mond*, p. 164.

No rise or fall in air-temperature of any amount occurs at new or full moon, though a tendency towards change seems clearly indicated shortly before full moon.[§]

The maximum effects, then, synchronising so nearly with the epochs of maximum and minimum exposure of the Moon's surface to solar radiation, seem to prove that our satellite is heated by the Sun.

5. The relation which has been thus traced between the Moon's heat and the daily variations of mean temperature, whilst it confirms the world-wide belief in lunar influence, reduces it to its real importance and frees it from the haze which has so long surrounded it. The effects produced would necessarily vary with the amount of cloud and vapour which from time to time happens to be present in the air; and this does not primarily depend upon the Moon.

Ewhurst, Dec. 24, 1867.

A Determination of the Moon's Mass. By E. J. Stone, Esq.

In a Note "On the Value of the Solar Parallax as deduced from the Parallactic inequality in the Earth's motion," printed in the last number of the *Monthly Notices*, I have deduced the value of the Moon's mass from the equations as given by Serret without the modifications introduced by Professor Newcomb. I have since determined these equations independently, retaining all terms of the third order in the Lunar Theory. My results do not agree with those obtained by Professor Newcomb. As the deduction of the Moon's mass from the theories of Precession and Nutation is a point of real importance, I print my results.

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[*] I found this to be the case on tabulating the mean amount of cloud and contemporaneous air-temperature at Greenwich in 1841-47. Both cloud and temperature were found to rise above the average on the three days preceding third quarter. And this was not caused, as I ascertained, by any change in the direction of the wind.

[†] See Hopkins' *Atmospheric Changes*, p. 333.

[‡] See *Annuaire du Bureau des Longitudes*, where Schübler and others are quoted as having found the minimum of cloud to occur after third quarter. *Ann.* 1833, p. 61.

[§] Herschel's *Lectures on Scientific Subjects*, p. 149.

I take γ to denote Delaunay's constant, which, in the first approximation, is equal to the sine ½ (inclination of lunar orbit); a, a_1 the *mean* distances of the Moon and Sun; e, e_1 the excentricities of the lunar and solar orbits; κ a constant depending on the Sun's mean disturbing force, the moments of inertia of the Earth, and the Earth's angular velocity; μ, the motion of the Moon's node, relatively to the line of equinoxes, in a Julian year;

$$\iota = \frac{\text{Moon's Mass}}{\text{Sun's Mass}} \, \frac{a_1^3}{a^3};$$

I then find

$$\text{Luni-Solar Precession} = \kappa \left[1 + \frac{3e_1^2}{2}\right] + \kappa\iota \left[1 + \frac{3e^2}{2} - 6\gamma^2\right],$$

$$\text{Constant of Nutation} = \kappa\iota \frac{2\gamma}{\mu}\left(1 + \frac{3e^2}{2} - \frac{5\gamma^2}{2}\right).$$

From which formula I find, with Luni-Solar Precession $= 50''\cdot378$ and Nutation $= 9''\cdot223$.

$$\frac{\text{Moon's Mass}}{\text{Earth's Mass}} = \frac{1}{81\cdot36}.$$

It appears to me that Serret's formulæ are not accurate to the third order. His e would no longer be a constant.

Jupiter and his Satellites. By Thomas Barneby, Esq.

Having had a clear view of the phenomenon on the 21st August last, soon after its commencement, and during the progress which I witnessed, I trust my observation may be recorded.

I used the whole aperture of my 9-inch Equatoreal, made by Mr. Cooke for the late Captain Jacob.

When I first saw the planet, the shadow of the *third* satellite only was on its disk. The *third* satellite itself next made its ingress, and I afterwards saw the several ingresses of the shadows of the *fourth* and *first* satellites, and of such satellites.

The *second* satellite had then become eclipsed, leaving no satellite visible, except on the face of the planet.

The three shadows were perfectly black, and there was no perceptible penumbra, although the outlines were not so clearly defined as I have seen them with a smaller instrument.

The three satellites, when on the disk, were of different colours, the *first* was the lightest and brightest, resembling most its colour when off the disk, and the *fourth* was as black as its shadow.

The *third* satellite was generally of a cinnamon colour, but on its south-western side there was a large double spot of a much darker cinnamon or sponge colour. These markings were very peculiar, and are well delineated in Mr. Dawes's paper in the *Monthly Notices* of November last. I have before described them, as on the apparent east side, which accords with the south-western side, allowing for inversion and the position of the planet.

The belts in the neighbourhood of the equatorial regions of the planet were illuminated with a brilliant rose-coloured tint, which added much to the beauty of the view, and reminded me forcibly of a terrestrial "Evening-red" of more than ordinary magnificence.

South Villa Observatory, Worcester,
16th December, 1867.

Results of the Observations on Sun-spots made in Kew and in Dessau during the Year 1867. Communicated by Messrs. De La Rue, Stewart, and Loewy.

	Kew.				Dessau.			
Months.	No. of new Groups.	Numbers.	Days of Obs.	Days without Spots.	No. of new Groups.	Numbers.	Days of Obs.	Days without Spots.
January	0	..	6	6	0	..	23	23
February	0	..	10	10	0	..	26	26
March	3	770 to 772	10	6	3	1 to 3	26	15
April	2	773 to 774	15	9	1	4	24	16
May	1	775	13	9	2	5 to 6	26	16
June	0	..	13	11	1	7	30	23
July	2	776 to 777	19	14	2	8 to 9	31	18
August	0	..	0	..	3	10 to 12	31	20
September	1	778	8	0	1	13	30	17
October	3	779 to 781	11	3	3	14 to 16	28	13
November	2	782 to 783	10	3	4	17 to 20	22	5
December	3	784 to 786	5	1 (?)	5	21 to 25	15	3
Total	17	770 to 786	120	72	25	1 to 25	312	195

Remarks.—The numbers in the Kew list form a continuation of the Catalogue of Groups, published in the first series of "Researches in Solar Physics," by Warren De La Rue, Balfour Stewart, and Benjamin Loewy, pp. 6–8.

Those days on which it is doubtful whether spots were on the Sun or not, have the sign (?) after them.

Necessary repairs and alterations in the Kew dome caused an interruption in the regular work of the Photoheliograph from August 9th to September 9th.

Although the number of groups observed is the lowest since the commencement of regular Sun observations in 1825, still there were among the number several of very considerable size (March 31, April 5 and 6, and September 9–21). Large solitary spots made their appearance towards the end of the year.

Hofrath Schwabe reports that the uniform brightness of the Sun's surface observable, is the beginning of the year, and the almost total absence of faculæ, both of which phenomena were some time ago submitted to the attention of the Fellows of the Royal Astronomical Society, have disappeared, and that since October the luminosity has again diminished near the edge.

On November 12th, 2^h P.M. (Dessau M.T.), during a very short glimpse of sunlight, he observed near the limb two or three luminous bodies of a cloudlike, fleecy appearance, quite similar to those which he has observed in former years; unfortunately he had no time to study them more closely.

Note on the Variable Star, T *Serpentis*.

1869, $\alpha = 18^h\ 21^m\ 59^s$; $\delta = +6°\ 12{\cdot}7$. By J. Baxendell, Esq.

This Variable was discovered at Mr. Worthington's Observatory, Crumpsall, in July, 1860, as an outlier of the fine Cluster, No. 72 of Sir William Herschel's 8th class, and a brief account of it was inserted in the *Monthly Notices* for January, 1861; but as it appears not to have been seen since by other observers, and may therefore be supposed to have been merely a temporary star, I have thought it desirable to communicate to the Society the results of all the observations I have hitherto made.

Observed maxima of T *Serpentis*:—

1861	May 12	10·5 mag.
1862	April 17	10·7
1863	April 1	11·0
1866	Dec. 10	11·0
1867	Nov. 25	10·3

Equating, and treating by the method of least squares, we have

Epoch = 1864, Feb. 29.
Mean period = 340·5 days.

Calculating the times of maximum from these elements, we have the following differences between the calculated and the observed times:—

C – O in days
+ 1·5
+ 2·0
– 6·5
+ 6·5
– 3·0

The greatest difference being only *one fifty-second* of the mean period, it appears that T *Serpentis* belongs to the list of moderately regular periodical variables. When at minimum it is below the 14th magnitude. Its next maximum is due 1868, October 27·5, at which time it will be favourably situated for observation.

Cheetham Hill, Manchester.
January 8, 1868.

On the Maximum of U *Geminorum.* By G. Knott, Esq.

I beg to offer to the Society the following observations of the maximum of Mr. Hind's curious variable star U *Geminorum*, which occurred in December last. The observations were made with my 7⅓-inch Alvan Clark refractor, the magnitude of the variable on each occasion being deduced from a careful comparison with a selected list of neighbouring stars. The light-ratio of the magnitude scale employed is 2·512.

Observations of U *Geminorum.*

Date.	h m	Mag.	Remarks.
Dec. 3 1867,	9 20 G.M.T.	under 13	Not seen.
7	10 25	9·4	U bluish white, disk ill-defined.
12	11 10	9·6	Moonlight, and clouds troublesome.
18	8 0	11·05	U rather large for its mag., shining with a dull bluish white light.
22	8 45	13·7	Rather brighter at intervals?
27	11 10	14·0	
31	10 55	14 ±	Feebly glimpsed. Sky rather hazy.

The observations are not sufficiently numerous to enable me to determine the date of maximum with great nicety, it would appear, however, to have occurred on December 8th, about nine days later than the calculated date of maximum deduced from the elements given by Dr. Schönfeld in his "Catalogue of Variable Stars."

The rapidity with which this remarkable star goes through its changes, the irregularity of its period, its hazy appearance and peculiar hue, and the curious fluctuations of brightness in short intervals of time which have been sometimes observed, point it out as an object well worthy of careful attention on the part of astronomers.

It is much to be wished that observations of its spectrum could be obtained, as the peculiarity of its appearance suggests the probability that its spectrum would be found to be characterised by the presence of ***bright lines.***

Woodcroft Observatory, Cuckfield,
January 9, 1868.

Companion to γ Equulei. By G. Knott, Esq.

On the 9th of July, 1867, I discovered a minute and pretty close companion to *γ Equulei*, which, so far as I am aware, had not been previously observed. Measures with a parallel wire micrometer on the same evening, and on that of July 27th, gave the following mean results:—

$P = 276^{\circ}\cdot84$, obs. 11, w. 53; $D = 2''\cdot131$, obs. 8, w. 24; Epoch 1867·54.

The small star is about the 11th magnitude (corresponding with about the 10th mag. of Struve's Scale), and its colour, a fine clear blue, contrasts finely with the pale yellow of the primary.

Woodcroft Observatory, Cuckfield,
January **9, 1868.**

Ephemeris for the Opposition of Iris, 1868, *computed from his Tables of Iris.* By F. Brunnow, Esq., Astronomer Royal for Ireland.

Berlin M.T.	App. R.A.	App. Decl.	Log. Dist. from Earth.
	h m s	° ′ ″	
1868, March 27·5	13 30 11·15	−17 2 22·7	0·28340
28·5	29 19·43	16 57 40·6	0·28252
29·5	28 27·03	16 52 49·6	0·28170
30·5	27 34·00	16 57 50·0	0·28094
31·5	26 40·39	−16 42 41·9	0·28025

Berlin M.T.	App. R.A.	App. Decl.	Log. Dist. from Earth.
	h m s	° ′ ″	
April 1·5	13 25 46·27	−16 37 25·8	0·27962
2·5	24 51·69	16 32 1·9	0·27905
3·5	23 56·71	16 26 30·6	0·27855
4·5	23 1·39	16 20 52·2	0·27811
5·5	22 5·79	16 15 6·9	0·27773
6·5	21 9·97	16 9 15·0	0·27742
7·5	20 13·98	16 3 16·8	0·27718
8·5	19 17·87	15 57 12·7	0·27700
9·5	18 21·71	15 51 2·8	0·27689
10·5	17 25·55	15 44 47·7	0·27684
11·5	16 29·44	15 38 27·7	0·27686
12·5	15 33·46	15 32 3·1	0·27695
13·5	14 37·65	15 25 34·3	0·27711
14·5	13 42·09	15 19 1·8	0·27733
15·5	12 46·81	15 12 26·0	0·27762
16·5	11 51·89	15 5 47·4	0·27797
17·5	10 57·37	14 59 6·2	0·27839
18·5	10 3·31	14 52 22·9	0·27888
19·5	9 9·77	14 45 37·7	0·27943
20·5	8 16·81	14 38 51·2	0·28005
21·5	7 24·50	14 32 3·7	0·28073
22·5	6 32·87	14 25 15·8	0·28148
23·5	5 41·99	14 18 27·9	0·28228
24·5	4 51·89	14 11 40·5	0·28315
25·5	4 2·63	14 4 53·9	0·28408
26·5	3 14·26	13 58 8·6	0·28507
27·5	2 26·81	13 51 25·1	0·28612
28·5	13 1 40·33	−13 44 43·9	0·28723

Opposition, April 12, $12^h\ 3^m\ 34^s{\cdot}8$ Berlin M. Time.

The Lunar Crater Linné. By Capt. W. Noble.

Since the appearance of Mr. Birt's letter in the 27th volume of the *Monthly Notices*, p. 93, "On the Obscuration of the Crater *Linné*," I have (in common, I suppose, with every possessor of a telescope) from time to time examined *Linnæus*, with a view to detecting any change which might conceivably be in progress in it. Up to a very recent period, indeed, all such examinations have had an entirely negative result. In the place where Beer and Mädler depict an annular crater I have hitherto seen nothing but a small ill-defined white patch or spot, with soft edges; presenting, even under the most favourable illumination, the aspect of any other small crater, near the centre of the lunar disk, at the time of full Moon, though without the sharpness of outline which would characterize it.

Subsequently to reading the paper by my friend Mr. Huggins, too, at p. 296 of the last volume of the *Notices*, I made an attempt to get a glimpse of the minute crater which he there depicts, but, as before, without effect. Ultimately I made up my mind that my optical means were insufficient for the scrutiny, and gave myself very little more trouble about it.

It was with no small surprise then, that, on looking at the *Mare Serenitatis*, at 5^h on the evening of Sunday, the 3rd November, I was struck by seeing *Linnæus* as an unmistakeable shallow crater, of somewhat elliptical form, and with the S.W. part of its surrounding wall rather thicker than the remaining portion. The floor of the crater was identical in tint with the surrounding *Mare*, and the effect presented at once suggested the aspect of the well-known nebula 57 *Messier*, between β and γ *Lyræ*. I was employing a power of 154 on my 4·2-inch achromatic of 61 inches focal length, when I first caught sight of *Linné*, but exchanged this for one of 255 for confirmation of detail. It is with the last-named power that the accompanying sketch* was made. I did not attempt any micrometrical measurements, but contented myself by drawing, with my eye at the telescope, what I saw at moments of the best vision. The extreme shallowness of *Linnæus* was curiously shown by the contrast presented by the remarkable blackness of the shadows of the minute craters to the north of it.

The Lunar Crater Linné. By J. Joynson, Esq.

On the 1st January, 1868, at 8^h P.M., it was not easy to make out where *Linné* exactly was in the field of the telescope, and when found it was far from being bright, and looked ill-defined and flattish. It appeared as though it was situated in a sort of trough formed by two "veins" or "ridges," that trended past it about due South, which "veins" were judged to be higher than *Linné* itself, particularly that on the western side.

On the 3d January the above-mentioned "veins" could not be found, but *Linné* itself was distinctly seen as a small black crater very well defined, surrounded by the usual hazy brightness. The following and south following part of the crest of the crater was the brightest, but the whole crest looked bright by contrast with the deep blackness of the centre. The crater lays rather south preceding the middle of the hazy brightness; but when it was best seen, it looked as if the brightness was not so extensive as it usually appears, and the crater itself was very near the centre of it.

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* The sketch referred to closely resembles that given by Mr. Huggins, vol. xxvii. p. 296.—*Ed.*

The crater was found with a positive eye-piece of a power of about 400; and though it was afterwards seen with the ordinary eye-pieces, both negative and positive, yet it was with considerable difficulty, and would certainly not have been made out with them. I think it was best seen when the rest of the Moon's surface was a very little out of focus.

As the Moon got up to and past the meridian, it became more difficult to make out the crater; and at $7^h 40^m$ P.M. it required considerable attention to make it out at all, even with the before-mentioned eye-piece. At $7^h 15^m$ there appeared to be just above the crater a bright "spur" projecting out of the hazy brightness." The shallow crater could not be seen.

From what I have observed to-night, I am confirmed in the belief that there has been no change at all in *Linné* itself. The difference has been in observers, their instruments, and time of observation. I am convinced that I never should have seen the crater if I had not had this eye-piece, which, however, does not belong to the telescope. I use it with the microscope, and it was quite by chance that I have lately adapted it to and used it with the telescope. With the other eye-pieces *Linné* appears exactly as it did when I first observed it a year ago.

The measures of the whole brightness gave $4''\cdot42$, and those for the small black crater gave $1''\cdot223$; but I had to measure with the ordinary eye-pieces in the micrometer, which did not show it so well as might have been wished.

Waterloo, January 3, 1868.

On a Contrivance for reducing the angular Velocity of Meteors, so as to facilitate the observation of their Spectra. By John Browning, F.R.A.S.

When detailing to the Society some experiments I made, attempting to determine the characteristics of the spectra of the meteors of 1866, I stated that the great obstacle to any accurate observation arose from the enormous velocity with which the meteors travelled. This obstacle I have tried various means to overcome.

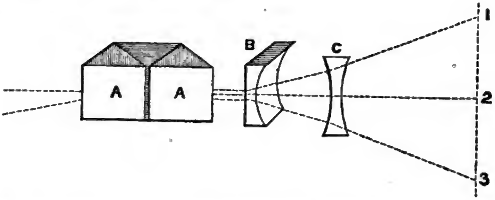
The contrivance I have found most promising consists of a direct-vision prism, having in front of it a deep concave cylindrical lens, and in front of that a double convex lens of the ordinary kind. Both these lenses should be either achromatic, or else made of optical crown glass of the lowest dispersive power.

The action of this piece of apparatus will become apparent upon referring to the accompanying diagram.

In this diagram A A represents a compound direct-vision prism; B, a plano-concave cylindrical lens; C, a double-concave lens with spherical curves of a much less curvature.

The dotted line represents the path of a meteor; the figures 1, 2, 3. three points in its path, and the lines proceeding from these three points, the manner in which the rays proceeding from the meteor are acted upon by the lenses and converged, so as to produce a comparatively stationary image in the prism.

The lens C, is useful in two ways. It assists in the converging action required, thus increasing the field, and it greatly improves the definition of lines in spectra, by bringing rays at right angles nearer to the same focus.



With the apparatus I have just described I have found it easy to obtain the spectra of balls shot from a Roman candle placed only a few yards off from the instrument. The angular velocity of the projected balls under these conditions is, of course, very great, yet the characteristic lines of baryta, strontia, &c., can be readily distinguished in their spectra.

I have the pleasure of exhibiting the apparatus adapted to a spectroscope similar to those I have made for the Royal Society under Mr. Huggins' instructions.

Our opportunities of observing meteors being very few, I have made this adaptation, so that the same apparatus may be used for various purposes.

The Meteor Epoch of November 13–14, 1867.

By V. Fasel, Esq.

The early part of the night of November 13–14 was not very favourable, the sky being rather overcast. Soon after 8^{h} P.M. it nevertheless cleared up so much as to induce me to make due preparations for keeping watch for the expected shower of meteors. After obtaining the true time from a transit of *Polaris* and other stars, I took my post outside the Observatory. What follows were the results of my watch:—

Nov. 13, at $11^{h}\ 40^{m}$ P.M. Wind E. b. N; high thin cirri in

W. S.W. current passed over the Moon, and when 10° East of it, they remained stationary for several minutes, and then gradually vanished.

11^h 41^m P.M. (G.M.T.). A meteor of the second magnitude shot from above the Pointers in *Ursa Major*, and travelled about 12° due South, towards *Castor* and *Pollux*. Its colour was red: it left a train of red light.

Nov. 14, 0^h 11^m A.M. Some light whitish clouds appeared in S.E. They came *rapidly* towards the Moon in a N.W. direction.

0^h 13^m A.M. A lunar corona, lightly coloured.

0^h 15^m A.M. Sky partially overcast with rapid flying thin scud in S.S.E. current.

0^h 30^m A.M. Sky overcast. At 0^h 40^m 28^s A.M., saw through the clouds a stationary meteor, which was visible between two or three seconds. Its position must have been in the constellation *Leo*. Its colour was red, and of the size of a tennis-ball.

From 0^h 40^m 28^s to 3^h A.M. the sky was quite overcast, but the Moon remained visible through the light clouds that continued to fly rapidly in S.E. current.

From 3^h A.M. to 4^h 30^m the Moon was invisible.

4^h 45^m A.M. Sky clearing up; a few stars visible.

5^h A.M. Fog coming on.

6^h A.M. Dense fog. Observations discontinued.

Clapham Observatory, November 14, 1867.

Meteoric Shower, November 1867, *observed at the Cape of Good Hope.* By G. W. H. Maclear, Esq.

I forward the results of the watches for the November Meteoric Shower, kept up at this Observatory on the nights of the 12th, 13th, 14th, and 15th.

Nov. 12th. Commenced watch at 8^h P.M., Cape Mean Time, terminating at daylight; only three meteors were observed, viz.—

h	m					
11	4	from	Taurus	to	Horizon	Large, blue and white.
11	45	,,	Procyon	,,	Northward	,, red.
11	55	,,	Zenith	,,	Westward	Very large.

Bright moonlight, and violent S.E. wind throughout.

Nov. 13th. Commenced watch 10^h 45^m, terminating at daylight; nine meteors observed, viz.—

h	m	s					
11	49	5	from	α Ceti	to	α Andromedæ	Small.
[illegible]1	50		,,	α Columbæ	,,	S. Pole	Larger, purple and white.
14	48		,,	Regulus	,,	S. Cross	Very fine, green train.

h	m					
14	51	from	Procyon	to	Gemini	Small.
15	35	,,	betw. Regulus and α Hydræ	to	β Corvi	Small.
15	41	,,	Regulus	to	Arcturus	Small, curved.
15	46	,,	,,	,,	Spica	Small.
15	49	,,	,,	,,	Gemini	,,
15	49	,,	,,	,,	,,	,,

Bright moonlight; very hazy low E.; violent S.E. wind throughout.

Nov. 14th. Seventeen meteors observed, principally from *Leo*.

h	m	s					
13	52	0	from	η Leonis	to	Regulus	Orange and green; small.
14	3	0	,,	below Procyon	to	Spica	,, ,, ,, ,,
14	9	0	,,	Procyon	to	Southward	White; long train.
14	18	0	,,	γ Leonis	,,	Spica	Bright; short period.
14	18	22	,,	η Leonis	,,	Gemini	Faint.
14	37	17	,,	Leo	,,	β Corvi	Bright.
14	51	52	,,	γ Leonis	,,	Spica	Small.
14	58	52	,,	,,	,,	,,	,,
15	7		,,	Leo	,,	Procyon	Very small.
15	13		,,	ι Leonis	,,	N.E.	,,
15	14	22	,,	Leo	,,	β Corvi	Green; short period.
15	17	17	,,	about 8° below Regulus	to	Spica	Large.
15	19	57	,,	Leo, below β Corvi,	to	Southward	,,
15	27	37	,,	ζ Leonis	,,	N.E. horizon	,,
15	30	7	,,	Leo	,,	Spica	Small.
15	33	52	,,	below Gemini	,,	Capella	,,
15	34	32	,,	above Regulus	to	Procyon	,,

Fine moonlight night; wind abated; sky clear.

Nov. 15th. Five meteors observed, viz.—

h	m	s					
12	36	44	from	α Hydræ	towards	Spica	Small.
12	39	49	,,	Procyon	,,	Leo	,,
13	27	39	,,	Gemini	,,	N. horizo	,,
13	45	44	,,	α Orionis	,,	,	,,
14	25	44	,,	Aldebaran	,,	,,	,,

Fine calm night; bright moonlight.

The station, as before, was on the roof of the Observatory, with an uninterrupted view of the horizon.

Royal Observatory, Cape of Good Hope,
November 19, 1867.

Meteoric Shower, November 1867, A.M., *off Martinique, West Indies.* Lat. 10° 44′, Long. 61° 11′ W.; Time 5h 20m to 6h 15m A.M. Local Time. Communicated by Commander W. Chimmo, commanding H.M.S. Gannet.

Rounding the north point of Martinique at 5 in the morning of the 14th November, while sitting on the bridge, I saw an immense number of bright sparks falling into the sea, at apparently a short distance from the ship, which I thought came from the ship's funnel, as they resembled those of sparks caused by the burning of wood.

I took no further notice until my attention was arrested by a brilliant meteor bursting in the East and emitting sparks like those of a rocket, shooting in a North direction at an altitude of about 37 degrees, and at an angle of 75 with the horizon.

I then called the attention of the First Lieutenant and Master, who were on the bridge at the time, to the meteoric shower then in view, falling rapidly and perpendicularly; every now and then a brilliant meteor bursting and lighting up the whole heavens. It was in reality a grand sight of fireworks.

The spot of blue sky from which they fell was about one-sixteenth of the whole heavens, and from the edge of a dark cloud of nimbus which was hanging over the island.

I merely send this as a simple notice for record, that the shower was seen at this place; but on board a ship, in the anxiety and excitement of going into a strange harbour, was not the time nor place to make any detailed observations.

This shower was much more distinctly seen at Trinidad on the same morning, from 2 A.M. to daylight, when 1600 were counted, and about eight per cent thought to have been missed. The meteors seen were numerous in the N.E., describing arcs of 60°. Some were of a reddish hue; others green, and one of a bright fiery purple, lasting many seconds. From midnight till 5h 30m A.M. 693 meteors were counted; 23 per cent were of the brightest description.

Trinidad, November 26, 1867.

Meteoric Shower, November 1867, *observed at Nassau, Bahamas.* By Captain Stuart.

(*Communicated by Samuel Lawson, Esq.*)

I forward for the information of the Society a table showing the character of the meteoric shower, as observed here on the morning of the 14th inst. The observer, an intelligent and experienced nautical man, was not advantageously placed for an extensive view of the heavens; and two other observers in a better position counted 1100 meteors between 2h 30m and 4h 45m A.M., up to which time Captain Stuart had counted only 800.

They observed them all round the heavens, from N.W. to S. and some overhead. From 4 A.M. the meteors appeared to radiate principally from a centre a little to the S.E. of the zenith, and shot in all directions. The position of Nassau is 25° 5′ N. lat. and 77° 22′ W. long.
S. L.

Government House, Nassau,
22nd November, 1867.

Observations with regard to the Meteoric Shower taken at Nassau, N.P., Bahamas (Lat. 25° 5′ N., Long. 77° 22′ W.), on the morning of the 14th Nov. 1867, by Captain Stuart, Deputy Inspector of Lighthouses.

	Proportion of sky clear.	Length of each period.	Number of Meteors seen	
			In each period.	Total from Commencement
		h m		
13th Nov. 11 0 P.M.	·3	...	...	...
14th Nov. 1 0 A.M.	...	...	...	...
At 1 32	...	...	1 *a*	1
,, 1 45	...	13	1 *b*	2
,, 1 50	...	5	1 *c*	3
,, 1 57	...	5	1	4
,, 2 0	·5	7	1	5
Before 3 0	...	3	17	22
,, 3 15	...	1 0	23	45
,, 3 30	...	15	52	97
,, 3 40	...	15	32	129
,, 3 50	·6	10	34	163
,, 4 0	...	10	49	212
,, 4 10	...	10	118	330
,, 4 15	...	10	125	455
,, 4 20	...	5	102	557
,, 4 25	...	5	73	630
,, 4 30	...	5	69	699
,, 4 35	...	5	66	765
,, 4 40	...	5	21	786
,, 4 50	...	10	52	838
,, 5 0	·8	10	64	902
,, 5 10	...	10	65	967
,, 5 20	...	10	22	989
,, 5 30	...	10	46	1035
,, 5 34	...	4	5	1040

REMARKS.

a. About 20° E. by N. from *Sirius*, whose altitude was 43° E. of meridian. Direction from N. to S.

b. 10° E. by N. from Polar Star. Altitude 25°, N. to S.

c. In the Great Bear, E. to W.

The proportion of sky visible to the observer, who was only a few feet above the level of the sea, was about ·6.

The Moon shone very bright between $3^h 45^m$ A.M. to daylight. She was about 30° W. of that part of the heavens, where the meteors were chiefly seen.

The direction of the meteors was N. to S. and E. to W., chiefly in that part of the heavens where the Constellation of the *Polar Bear* was, at the altitude of 45°.

No atmospheric or magnetic disturbance was caused by the Meteors while falling.

ERRATUM.

The Erratum, p. 16, should be as follows :—

Memoirs, Vol. XXXV.

In p. 25, columns 5 and 6 of the Table, Comparison with Struve's Stars (Place by Chart for 1826), of Star Struve 409, W. H. IV. 44,

For $3^h\ 31^m{\cdot}3$ 70° 48′, *read* $3^h\ 21^m +$ 79° 15′ ±.

CONTENTS.

Page
Fellows elected 37
Rotation of *Mars*, by Mr. Proctor ... ... ib.
Inductive Proof of the Moon's Insolation, by Mr. Harrison 39
A Determination of the Moon's Mass, by Mr. Stone 42
Jupiter and his Satellites, by Mr. Barneby 43
Results of the Observations on Sun-spots made in Kew and in Dessau during the Year 1867, by Messrs. De La Rue, Stewart, and Loewy ... 44
Note on the Variable Star, T *Serpentis*, by Mr. Baxendell 45
On the Maximum of U *Geminorum*, by Mr. Knott 46
Companion to γ *Equulei*, by Mr. Knott 47
Ephemeris for the Opposition of *Iris*, 1868, computed from his Tables of *Iris*, by Mr. Brunnow ... ... ib.
The Lunar Crater *Linné*, by Capt. Noble 48
Ditto ditto by Mr. Joynson 49
On a Contrivance for reducing the Angular Velocity of Meteors, so as to facilitate the observation of their Spectra, by Mr. Browning 50
The Meteor Epoch of November 13–14, 1867, by Mr. Fasel 51
Meteoric Shower, Nov. 1867, at the Cape of Good Hope, by Mr. Maclear 51
Ditto ditto off Martinique, by Comm. Chimmo 54
Ditto ditto at Nassau, Bahamas, by Capt. Stuart ... ib.
Erratum 56

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

GENERAL LIBRARY
University of MICHIGAN

Vol. XXVIII. *February* 14, 1868. No. 4.

Rev. Charles Pritchard, M.A. F.R.S., President, in the Chair.

Charles Henry Brooks, Esq., Merton, Surrey;
George Stickland Criswick, Esq., Royal Observatory, Greenwich;
Lieut. Seymour Morse Davies, R.A., Upton Park, Slough; and
John Parnell, Esq., Hadham House, Upper Clapton,

were balloted for and duly elected Fellows of the Society.

Report of the Council to the Forty-eighth General Meeting of the Society.

Progress and present state of the Society:—

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
December 31, 1866	173	278	14	4	469	47	516
Since elected ...	8	21	...	...	...	...	...
Deceased	−3	−6	−1	...	...	−1	...
Expelled	...	−1	...	...	...	...	...
Resigned	...	−5	...	...	...	...	...
Removals	+1	−1	...	...	...	...	...
Dec. 31, 1867 ...	179	286	13	4	482	46	528

Mr. Whitbread's Account as Treasurer of the Royal Astronomical Society, from January 1 to December 31, 1867:—

RECEIPTS.

	£	s.	d.	£	s.	d.
Balance of last year's account	95	14	7			
Plus: Pearson's cheque lost and unpaid, for which a second cheque was given	2	10	0			
				98	4	7
By Dividend on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents	73	15	0			
By ditto on £2800 Consols	41	6	0			
By ditto on £5000 New 3 per Cents	73	15	0			
				230	2	0
On account of arrears of contributions	199	10	0			
176 annual contributions	368	11	0			
28 admission-fees	58	16	0			
19 first years' contributions	33	12	0			
	660	9	0			
10 compositions	207	18	0			
				868	7	0
Sale of publications				80	12	6
				£1277	6	1

EXPENDITURE.

	£	s.	d.	£	s.	d.
Salaries :—						
Editor of Publications	60	0	0			
Assistant Secretary	115	0	0			
Commission on Collecting	37	1	0			
				212	1	0
Taxes :—						
Land and Assessed	6	11	0			
Income	1	13	4			
Poor Rate	11	13	4			
Other Parish Rates	3	19	2			
				23	16	10
Repairs:—						
Boobbyer, ironmonger	3	2	0			
				3	2	0
Bills : —						
Strangeways and Walden, printers ...	601	17	8			
Rumfitt, bookbinder	12	5	1			
Basire, engraver	52	3	6			
Pearson, wood-engraver	8	2	0			
Joyce	1	5	0			
J. Beck	2	0	0			
Johnson and Co., engravers	13	13	0			
Wyon, medals	57	15	0			
Annual Dinner (deficiency)	18	12	0			
Insurance	10	0	6			
				777	13	9
Miscellaneous items :—						
House expenses	22	6	3			
Postages	42	12	6			
Books and parcels	3	14	5			
Expenses of evening meetings	13	13	0			
Waiters attending meetings	3	17	0			
Coals and wood	12	0	0			
Gas	5	4	10			
Repairs	5	8	0			
Sundries	16	7	2			
				125	3	2
Turnor Fund	3	12	3			
Mrs. Jackson's annuity, 1 year	8	13	4			
Mrs. Maynard. Gift	5	0	0			
				17	5	7
Cheque-book				0	5	0
				1159	7	4
Balance at Banker's				117	18	9
				£1277	6	1

Examined and found correct, 1868, February 3,
EDWIN DUNKIN, } *Auditors.*
Examined and found correct, Feb. 10th, 1868,
JOHN BROWNING. }

Assets and Present Property of the Society, January 1, 1868:—

	£	s.	d.	£	s.	d.
Balance at Banker's				117	18	9
2 Contributions of 6 years' standing ...	25	4	0			
12 ,, 4 ,, ...	100	16	0			
19 ,, 3 ,, ...	119	14	0			
25 ,, 2 ,, ...	105	0	0			
41 ,, 1 ,, ...	86	2	0			
2 admission-fees, and first contributions ...	6	6	0			
				443	2	0
Due for Publications				2	14	6
£5000 New 3 Per Cents (including Mrs. Jackson's Gift, £300).						
£2800 Consols, including the Lee Fund (£100) and Turnor Fund (£500).						
Unsold Publications of the Society.						
Various astronomical instruments, books, prints, &c.						
Balance of Turnor Fund (included in Treasurer's Account)				112	11	6

Stock of volumes of the *Memoirs*:—

Vol.	Total.	Vol.	Total.	Vol.	Total.
I. Part 1	14	XI.	191	XXIV.	192
I. Part 2	54	XII.	198	XXV.	202
II. Part 1	72	XIII.	210	XXVI.	210
II. Part 2	36	XIV.	400	XXVII.	449
III. Part 1	89	XV.	179	XXVIII.	425
III. Part 2	108	XVI.	204	XXIX.	446
IV. Part 1	108	XVII.	201	XXX.	200
IV. Part 2	120	XVIII.	183	XXXI.	184
V.	134	XIX.	195	XXXII.	212
VI.	155	XX.	188	XXXIII.	224
VII.	179	XXI. Part 1	316	XXXIV.	230
VIII.	165	XXI. Part 2	100	XXXV.	415
IX.	168	XXI. (together).	97	XXXVI. (with M. N.)	483
X.	181	XXII.	187	XXXVI. (without)	120
		XXIII.	186		

The instruments belonging to the Society are as follows:—

The *Harrison* clock,
The *Owen* portable circle,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Herschelian* 7-foot telescope,
The *Greig* universal instrument,
The *Smeaton* equatorial,
The *Cavendish* apparatus,
The 7-foot Gregorian telescope (late Mr. Shearman's),
The Variation transit (late Mr. Shearman's),
The Universal quadrant by Abraham Sharp,
The *Fuller* theodolite,
The Standard scale,
The *Beaufoy* clock, No. 1,
The *Beaufoy* clock, No. 2,
The *Wollaston* telescope,
The *Lee* circle,
The *Sharpe* reflecting circle,
The *Brisbane* circle.

The *Sheepshanks'* collection of instruments, viz.,—

1. 30-inch transit, by Simms, with level and two iron stands.

2. 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumbline; portable clamping foot and tripod stand.

3. $4\frac{6}{10}$ achromatic telescope, about 5 feet 6 inches focal length; finder, rack motion; double-image micrometer; object-glass micrometer; two other micrometers; one terrestrial and ten astronomical eyepieces, applied by means of two adapters, with equatorial stand and clock movement.

4. $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.

5. $2\frac{3}{4}$-inch achromatic telescope, with stand; one terrestrial and three astronomical eyepieces.

6. $2\frac{3}{4}$ achromatic telescope, about 30 inches focus; one terrestrial and four astronomical eyepieces.

7. 2-foot navy telescope.

8. 45-inch transit instrument, with iron stand, and also Y's for fixing to stone piers; two axis levels.

9. Repeating theodolite, by Ertel, with folding tripod stand.

10. 8-inch pillar-sextant, divided on platinum, with counterpoise stand and horizon roof.

11. Portable zenith instrument, with detached micrometer and eyepiece.

12. 18-inch Borda's repeating circle, by Troughton.

13. 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms.

14. A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, with extra pair of parallel plates; tripod staff; in which the telescope tube is packed; repeating table; level collimator, with micrometer eyepiece; and Troughton's levelling staff.

15. Level collimator, plain diaphragm.

16. 10-inch reflecting circle, by Troughton, with counterpoise stand; artificial horizon, with metallic roof; two tripod stands, one with table for artificial horizon.

17. Hassler's reflecting circle, by Troughton, with counterpoise stand.

18. 6-inch reflecting circle, by Troughton, with two counterpoise stands, one with artificial horizon.

19. 5-inch reflecting circle, by Lenoir.

20. Reflecting circle, by Jecker, of Paris.

21. Box sextant and 3-inch plane artificial horizon.

22. Prismatic compass.

23. Mountain barometer.

24. Prismatic compass.

25. 5-inch compass.

26. Dipping needle.

27. Intensity needle.

28. Ditto ditto.

29. Box of magnetic apparatus.

30. Hassler's reflecting circle, with artificial horizon roof.

31. Box sextant and 2¼-inch glass plane artificial horizon.

32. Plane speculum artificial horizon and stand.

33. 2½-inch circular level horizon, by Dollond.

34. Artificial horizon roof and trough.

35. Set of drawing instruments, consisting of 6-inch circular protractor; common ditto; 2-foot plotting scale; two beam compasses and small T square.

36. A pentagraph.

37. A noddy.

38. A small Galilean telescope, with the object lens of rock-crystal.

39. Six levels, various.

40. 18-inch celestial globe.

41. Varley stand for telescope.

42. Thermometer.

43. Telescope, with the object-glass of rock crystal.

These are now in the apartments of the Society, with the exception of the following, which are lent, during the pleasure of he Council, to the several parties under mentioned, viz.:—

The *Fuller* theodolite, to the Director of the Sydney Observatory.

The *Beaufoy* transit, to the Observatory, Kingston, Canada.

The *Sheepshanks* instrument, No. 1, to Mr. Lassell.
Ditto ditto No. 2, to Mr. De La Rue.
Ditto ditto No. 3, to Major Tennant.
Ditto ditto No. 4, to Rev. C. Lowndes.
Ditto ditto No. 5, to Mr. Birt.
Ditto ditto No. 6, to Rev. J. Cape.
Ditto ditto No. 8, to Rev. C. Pritchard.
Ditto ditto No. 9, to the Director of the Sydney Observatory.
Ditto ditto No. 41, to Rev. C. Pritchard.
Ditto ditto No. 43, to Mr. Huggins.
The 6-inch circular protractor, to Mr. Birt.

The Gold Medal.

The Council have awarded the Gold Medal to M. Leverrier for his Solar and Planetary Tables. The President will, in the usual way, explain the grounds of this award.

Printed Transactions of the Society.

Two volumes of *Memoirs* have been published since the last Report. Volume XXXV. contains four papers. Two of them are by Sir Thomas Maclear of observations made at the Cape of Good Hope. The former of these consists of the "Mean North Polar Distances of *Rigel*, *α Orionis*, *Sirius*, and *α Hydræ*, for January 1 of each Year, derived from Observations with the Transit Circle, in the Years 1856–63." The second paper contains "Geocentric Right Ascensions and North Polar Distances of Encke's Comet." The third paper is a valuable "Synopsis of all Sir William Herschel's Micrometrical Measurements and Estimated Positions and Distances of the Double Stars described by him, together with a Catalogue of those Stars, in order of Right Ascension, for the Epoch 1880·0," by Sir John F.W. Herschel.

This volume also contains, from the pen of the Rev. W. R. Dawes, a very important and extensive "Catalogue of Micrometrical Measurements of Double Stars, comprising all the measures obtained by him between the close of his Second Series (published in the *R. A. S. Memoirs*, vol. xix.) and the present time."

Volume XXXVI. consists of the observations made by Mr. Lassell during his last sojourn at Malta. These observations are arranged in three papers: I. Observations of Planets and Nebulæ; II. Miscellaneous Observations; III. A Catalogue of New Nebulæ discovered at Malta. Mr. Lassell's observations are illustrated by eleven plates.

OBITUARY.

The Society has to regret the loss by death of the following Fellows and Associate:—

Fellows.—The Earl of Rosse.
Lord Wrottesley.
Sir James South.
Rev. W. R. Almond.
Rev. Dr. Nicholson.
Mr. William Brooke.
Mr. J. J. Downes.
Mr. Charles Howell.
Rev. Miles Bland.
Mr. Thomas Heelis.

Associate.—Dr. Bache.

A notice of the life and labours of Lord Rosse will appear, it is expected, in the *Monthly Notices* for April.

JOHN, SECOND BARON WROTTESLEY, was the eldest son of Sir John Wrottesley, Bart., of Wrottesley, near Wolverhampton, in Staffordshire, who was raised to the Peerage as Baron Wrottesley. He was born on the 5th of August, 1798, and graduated first class in Mathematics at Oxford in 1817, being a Member of Corpus Christi College. He succeeded his father in the Barony on the 16th of March, 1841.

Taking much interest in Practical Astronomy, he became, as Mr. John Wrottesley, an original Member of this Society, and contributed various observations, chiefly of the stars, to its *Monthly Notices* and *Memoirs.* In the year 1829 he commenced the erection of an Observatory at Blackheath, where he began to observe, assisted by Mr. John Hartnup (afterwards Assistant-Secretary to the Royal Astronomical Society and now Astronomer of the Observatory at Liverpool), in the spring of 1831; having a transit-instrument by Thomas Jones, of 62 inches focal length, and clear aperture 3¾ inches, and a clock by Hardy. Being provided with such means of making astronomical observations, he determined to fix upon some definite object, and steadily pursue that alone. He, accordingly, selected 1318 stars from the Astronomical Society's Catalogue of 2881, being the stars of the sixth, and from that to the seventh magnitude inclusive, resolving to determine their right ascensions, observing, if possible, each star at least ten times. Having ascertained everything necessary to be known respecting the qualities of the instruments about to be employed, Mr. Wrottesley began the observation of his Catalogue on the 9th of May, 1831, and on the 1st of July, 1835, the task was brought to a conclusion. The Catalogue so produced embodies the results of 12,007 observations, exclusive of those of the stars required for comparison. It was read before this Society on the 11th November, 1836, and published in the Society's *Memoirs*, vol. x.

The Council awarded the Gold Medal to the author, to whom it was presented by the President, the late Mr. F. Baily, at the Annual General Meeting of February 8, 1839, after he had delivered an appropriate address, in which he informed the Society that when the requisite comparisons had been made with the positions of the same stars obtained at the public observatories,—and every star in Mr. Wrottesley's Catalogue, he also stated, had undergone that investigation,—the result had shown that his Catalogue was of first-rate importance, and entitled to implicit confidence. A Supplemental Catalogue of the right ascensions of fifty-five Stars, also observed at Blackheath, appears in the 12th volume of the *Memoirs*. At the Annual Meeting of 1841, Mr. Wrottesley was elected President, in which capacity, after his accession to the title of Lord Wrottesley, he delivered two addresses, on the presentation of the Gold Medal to Professor Hansèn, of Gotha, in 1842, for his researches in physical astronomy, and to Mr. F. Baily, in the following year, for the experiments in which he virtually repeated the Cavendish experiments to determine the mean density of the Earth. On April 29th, 1841, he had been elected a Fellow of the Royal Society.

In the beginning of the year 1842, Lord Wrottesley resolved on erecting an observatory near his residence, Wrottesley Hall; and on the 29th of March in that year, the first stone was laid by his youngest son, the late Cameron Wrottesley, Lieut. R.A., who had distinguished himself by his mathematical attainments, and had begun his career as an astronomical observer, which was unhappily terminated by his being killed at the siege of Bomarsund in 1854. The observatory was designed to contain the transit-instrument, with which the stars of the Blackheath Catalogue had been observed, and an equatorial telescope, with rooms for the observer. The observatory is described, and a plan of it given, in the introduction to the Catalogue of Stars in that of the British Association, of which an account is subjoined. The telescope is an achromatic, of 10 feet 9 inches focal length, with an object-glass of 7¼ inches clear aperture, of which the flint-glass is by Guinand and the crown by the elder George Dollond, who gave the curves to the glasses and completed the instrument. The years which immediately succeeded the foundation of the Wrottesley Observatory were employed in obtaining its position (N. Lat. 52° 37′ 23″, Longitude West of Greenwich in time $8^m\ 53^s{\cdot}57$), and in observations with the equatorial, which Lord Wrottesley communicated to the Royal Society, and which have been published in the *Philosophical Transactions* for 1851. This communication is entitled, "On the Results of Periodical Observations of the Positions and Distances of Nineteen of the Stars in Sir John Herschel's Lists of the Stars favourably situated for the Investigation of Parallax, contained in Part iii. of the *Phil. Trans.* for 1826, and in Part i. of 1827." The inquiry to which it relates constitutes another example of the mode of doing good service to Astronomy which Lord Wrottesley early prescribed to himself, and which he has steadily pursued.

Sir J. F. W. Herschel had shown in the papers referred to, and again in his Treatise on Astronomy, that if a star which is optically, though not physically, double (that is, one the component single stars of which appear in close proximity merely on account of their being nearly in the same line of sight, though at different distances from the eye, and not because, revolving about each other in orbits, they constitute a binary system), occupy a certain position with respect to the ecliptic, and one of the components be very much nearer the earth than the other, a considerable periodical and parallactic change will take place in their angle of position, or the angle made with the meridian, by a line drawn through both of them, and that the maximum variation from the mean position will occur at two opposite seasons of the year. Lord Wrottesley determined to devote his equatorial to a good trial of this method of discovering parallax, and six years' uninterrupted observing, from February 1843 to October 1849, by his assistant and himself, was given to the work. But the observations were attended with great difficulties, and of sixty-nine double stars selected, only forty-eight were observed, and only nineteen at both periods of the year. Of these again, the observations of five only deserved much attention, as exhibiting indications of parallax measurable by this method; but two of them, 32 *Eridani* and 95 *Herschel*, Lord Wrottesley finally recommended to the notice of astronomers provided with adequate instruments for observing them. Thus the principal result of the labour and assiduity bestowed on this object was the illustration of the practical difficulty of the method, and it demonstrated the impolicy of further perseverance, with the instrumental means of the Wrottesley Observatory, especially as instruments had been erected, both at Liverpool and Oxford, pre-eminently suited to this class of observations. But the zeal which prompted the employment of so much time and force by one astronomer, in the pursuit of a mode of research, proposed to observers by another, deserves the commendation of every lover of science. The paper is worthy of attention in another point of view. The importance to the correction and advancement of knowledge of recording failures, and imperfect success in research, has been insisted upon by the highest authorities; modern astronomers have been conspicuous in acting on this principle, and have thus encouraged labourers in other departments to submit to the task so unpleasing to themselves, though so beneficial to their successors; and the candour with which Lord Wrottesley has estimated the amount of success obtained in this arduous inquiry, is equalled only by the devotion and skill displayed in making and discussing the observations.

When the Star-Catalogue of the British Association appeared, he was anxious to perform the same office in respect to that most valuable publication which he had already undertaken and performed in reference to the prior Catalogue of the Astronomical Society. For this purpose he selected 1009 stars, with the intention of obtaining, at least, five observations of each, being those stars which had already been observed at Blackheath, and had been discovered to possess proper motion, with others selected on various accounts.

The observations were begun on the 1st January, 1850, and concluded on the 24th December, 1853. They were all made and computed by Lord Wrottesley's assistant, Mr. Richard Philpott, an excellent transit observer, aided in the computations by his second assistant, Mr. Frederic Morton, who had charge of the equatorial. The results were communicated to the Royal Astronomical Society, read on the 13th of January, 1854, and published in vol. xxiii. of the *Memoirs*, being alluded to with great approbation by the Council in the Report for February 9th, 1855.

On the resignation of the late Earl of Rosse, Lord Wrottesley was proposed and chosen President of the Royal Society, at the Anniversary Meeting of 1854, and was re-elected to that office in the three following years. Having thus been placed at the head of the most ancient and venerable of British scientific institutions, he availed himself of the first opportunity afforded him, according to established usage, of addressing the Royal Society, at the Anniversary of 1855, of taking a review of some of the desiderata of science in this country, with respect both to the wants of the public, and to the interest and encouragement of the nation and the government. In his address of 1856, he resumed the consideration of the requirements and actual condition of scientific knowledge, in connexion with the occupation of Burlington House by the Royal Society, in conjunction with the Linnean and Chemical Societies of London, to which an improved appreciation of science on the part of the existing administration had conduced.

In 1859, Lord Wrottesley communicated to the Proceedings of the Royal Society a paper, "On the Application of the Calculus of Probabilities to the result of measures of the Position and Distance of Double Stars." He remarked in this paper that the differences between mean results obtained on different evenings were greater in proportion than those of the separate or partial measures obtained on the same evening, which arose from chance errors of observation; and that this circumstance rendered the application of the formulæ of the calculus of probabilities to the reduction of the observations, embarrassing and difficult. The observations made after 1851 fully confirmed this anomaly. As the observations of his Catalogue of Double Stars were drawing to a close, and it became extremely desirable that if there were any fault in the reductions or method of computing hitherto employed, it should be speedily remedied and the necessary corrections made, he requested and obtained the opinion as to the best mode of proceeding, of the Astronomer Royal, who proposed a formula adequate to the difficulties of the case, which is given in the paper, but which, though the correct one, he thought was too elaborate to use in dealing with observations in which the errors of observation were large in amount, and in which such extreme accuracy in the results is not attainable, as in some other cases to which the principles of the Calculus of Probabilities are applicable. Mr. Airy suggested, therefore, that all the observations of the several nights should be combined together for the purpose of obtaining the probable error and weight of the final result, which might be done in two ways. Lord Wrottesley accordingly proceeded to ascertain the result of employing each of these three methods, by directing his assistant, Mr. Morton, to observe three stars a very great number of times. The results are subjoined to the paper, together with the whole computation and a summary of them. "It is hoped," the author remarks, "that this may not only prove interesting to observers of double stars, but may throw some light on the curious mathematical question involved in the inquiry which is the subject of the above remarks." It appears from the entire investigation that little effect is produced on the mean result for each star by using these different methods of reduction.

The "Catalogue of the Positions and Distances of 398 Double Stars," for the sake of which the preceding discussions here recited were instituted, appeared in our *Memoirs*, vol. xxix., having been read May 11, 1860. In the introduction the author states that from the beginning of the year 1857, the final means were obtained, and the probable errors and weights computed, by considering all the observations of the star, on the different nights, to have been made on the same night.

The observations for the Catalogue were made by means of the equatorial telescope already noticed. As a general rule, ten measures, both in position and distance, were made on the same night of each object, whenever they could be obtained, but from March 1856 to October 1858 the practice was to take six measures only of each element. The ten or six observations, as the case may be, are called a set. There are, in fact, two Catalogues, the first containing the results of the observations of each star, made on separate nights; the second, the general mean of all the sets obtained in the same year.*

The production of this Catalogue appears to have been the last considerable work in Astronomy of Lord Wrottesley.

Lord Wrottesley married on the 28th of July, 1821, Sophia Elizabeth, third daughter of the late Thomas Gifford, Esq., of Chillington, Staffordshire, and had a numerous family; of whom two sons lost their lives in their country's military service.

Lord Wrottesley died at his ancestral residence on the 27th of October last, aged sixty-nine. E. W. B.

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* This Catalogue is noticed in the Report of the Council for February 8, 1861.

Sir James South was the son of a pharmaceutical chemist who carried on business in Southwark in the latter half of the last century. He was born in October 1785. After an ordinary course of education he entered upon the study of surgery, became a member of the College of Surgeons, and acquired an extensive practice and a reputation that promised eminence had he followed the profession. It is probable that his tastes were turned towards astronomy through an acquaintance which he early formed with Captain Huddart, a famous engineer, who, among other achievements, had constructed an equatorial mounting for a telescope with an object-glass of 3¾ aperture, made by Dollond, which instrument subsequently came into Mr. South's possession. Before obtaining this he had procured a 6-inch Gregorian reflector, with which he observed eclipses, occultations, and other phenomena. In 1816 he married the niece and sole heiress of Joseph Ellis, Esq., of South Lambeth, and, no longer dependent upon his profession, resolved to devote himself entirely to astronomical pursuits. He at once set about the formation of an observatory at his house in Blackman Street, Borough, and furnished it with the Huddart instrument above alluded to, a second telescope of 5 inches aperture, and a transit made for him by Troughton, upon the model of that which this eminent maker had recently constructed for the Royal Observatory, Greenwich; it was of 4 inches aperture and 7 feet focus, and, in regard to the just proportion of its parts, Troughton considered it as his happiest production.

Intent upon the useful employment of his time and resources, Mr. South resolved upon re-observing the double stars discovered and measured by Sir William Herschel. This appeared desirable, not only for the purpose of detecting changes of position, but on account of the improvement that had been wrought in the construction of measuring instruments since the epoch of the elder Herschel's observations. Sir John Herschel had projected a similar repetition of measures. A concerted plan of work was therefore agreed upon, and the observers began their labours in 1821, and continued them during the two following years. The result was the well-known Catalogue of 380 Stars, which was presented to the Royal Society in 1824, and printed at the expense of the Board of Longitude, and which was the standard work of its class till it was rivalled by that of Struve. Our Society rewarded Messrs. Herschel and South, jointly, with the Gold Medal for their labours in producing this Catalogue, which was honoured in like manner by the French Institute. Mr. South now entered upon a second series of similar observations; but finding the situation of his observatory not so good as he could wish for delicate work, he, in the autumn of 1824, transferred his larger instrument to Passy, near Paris, and worked there till towards the close of the following year, accumulating measures of 458 additional double stars. Upon his return to England, he observed for a time in Sloane Street, and made a re-examination of some of his French measures; this second Catalogue was printed in the *Philosophical Transactions* for 1826.

While working in concert with Sir John Herschel upon the first Catalogue he was using his transit instrument for an investigation bearing upon the errors of the Solar Tables then in use. The discordances between observed and calculated right ascensions of the Sun were generally attributed to instrumental inaccuracies caused by the heating of the instrument during the observations. Crucial tests were, therefore, instituted by Mr. South to verify or refute this supposition. For a time transits were taken with every possible precaution to shield the telescope from unnecessary exposure to sunshine. Then the sun was purposely allowed to shine upon one-half of the instrument for intervals varying from a few minutes to an hour before the time of transit, and series of observations were taken under these conditions. The observed places were compared with tabular places, and it was found from a mean of two years' observations that the difference between the errors derived from observations with the instrument defended and exposed amounted only to 0·045 of a second of time: it was, therefore, concluded that the discordances in question were not due to instrumental derangement, but belonged entirely to the tables. His paper on this subject and his labours upon double stars formed the grounds for the award of the Copley Medal to him in 1826.

The existence of an atmosphere of very great extent surrounding the planet *Mars* had been inferred from some observations by Cassini and Roemer, both of whom noted a considerable diminution in the brightness of a fifth-magnitude star occulted by the planet in 1672. This record prompted Mr. South to watch for appulses of *Mars* and stars, and he was fortunate in observing two near approaches and one actual occultation. In no case was any diminution of lustre or alteration of colour of the star detected beyond what was fairly attributable to the brightness and colour of the planet. Mr. South considered that his observations sufficiently negatived the conclusion derived from that of Cassini, but he commended the subject to further investigation, which, however, it has not received. In February 1821 he observed a remarkable occultation of δ *Piscium* by the Moon, when the star was projected to a considerable extent upon the unilluminated disk. This induced him to collect all available observations bearing upon the vexed question of projection. He analysed the recorded cases with reference to several explanatory hypotheses, viz. existence of a spurious disk in the Moon's image; existence of a lunar atmosphere; irradiation; imagination on the part of the observer; and differences of refrangibility of the light of Moon and star, arising from differences of colour. His examination led him to conclude that each and all of these were untenable, and he left the question where he found it, excepting that he had brought together a mass of materials to help any future investigator. The

Astronomer Royal, Mr. Airy, turned these to account, and increased the store: he took up the subject with a predilection for Mr. South's last-mentioned hypothesis, but finding it unsatisfactory, gave his adhesion to that attributing the apparent projection to irradiation in conjunction with some unexplained condition of the observer's mind or eye. This contribution of Mr. South's to astronomical literature appears in the *Memoirs* of our own Society, to which he had previously communicated several papers, relating to observations of comets and phenomena, adjustment of instruments, and methods of observation. Apart from his contributions to our *Memoirs*, the name of South will for ever be inseparable from the history of our Society; he was one of its founders, and, in the position of President, petitioner for the Charter by which, in 1831, it was incorporated. Immediately after procuring the charter, however, he ceased to take part in the Society's proceedings; the cause of his secession being a difference, into which it is needless to enter, concerning the tenure of the Presidency.

About the year 1826 Mr. South sought a better location for his instruments, and purchased a site at Campden Hill, Kensington, upon which he erected a magnificent Observatory, one of the most complete that private taste has yet called for. Besides the instruments removed from Blackman Street, it was furnished with the Transit Circle used by Groombridge in the formation of his Catalogue, and a clock presented by the King of Denmark. Mr. South intended to have a first-class equatorial, and procured from France a 12-inch object-glass by Cauchoix. A dome was prepared to receive the instrument, the manufacture of which was intrusted to Troughton, in whom South had unqualified confidence. The transaction was a very unfortunate one; the equatorial turned out, in South's opinion, a failure; bitter enmities were aroused, and the payment of the manufacturer became the subject of a lawsuit: the verdict was unfavourable to South, who forthwith demolished the instrument: every part of the mounting was broken up or mutilated beyond renovation, and the *débris* was sold as old metal by public auction. The object-glass was presented to the Dublin Observatory in 1862.

It was in 1831, while this instrument was in course of construction, that the honour of knighthood was conferred upon South, on the recommendation of the Duke of Wellington, then Prime Minister; subsequently a pension of 300*l.* a-year was granted for his contributions to Astronomical Science.

The unhappy affair of the equatorial in a great measure alienated Sir James South from astronomical pursuits. He published no more observations, but he did some work with his meridian instruments; he also devoted much time to experiments upon clocks and pendulums, the results of which may yet be rendered serviceable by publication. In 1846, when a line of railway was projected to pass near the Greenwich Observatory, of which establishment Sir James was a Visitor, he made a series of observations at Watford upon disturbances produced by passing trains upon the images of stars reflected from mercury; these were reported to the Government at the time, and were presented to the Royal Society in 1863.

Sir James South was the author of several papers and pamphlets of critical nature and severe tone. One of these, published in 1822, was an exposition of the then defective state of the *Nautical Almanac* as compared with the Continental Ephemerides: this subject received considerable discussion, and ultimately a committee was formed, with Sir James as its chairman, to report to the Admiralty upon it. To the recommendations of that committee the present excellence of the *Nautical Almanac* is due. The "Thirty-six Charges" preferred by South, in 1830, against the President and Council of the Royal Society were less satisfactory; although they were strongly pressed and freely circulated, they were never supported, and no notice was taken of them. He printed some minor papers in the *Quarterly Journal of Science* and *Phillips' Annals of Philosophy.*

During the last years of his life he was afflicted with nearly total deafness and partial blindness; bodily sufferings still further weighed him down till he sank beneath them on the 19th of October, 1867. J. C.

Alexander Dallas Bache was a great-grandson of the famous philosopher, Benjamin Franklin, and the son of Richard Bache, an able journalist. He was born at Philadelphia on the 19th of July, 1806. He graduated at the Military Academy at West Point, and at the end of the four years that determine the course of study at that institution, stood at the head of his class. The appointment of Assistant-Professor of Engineering in the Academy was immediately conferred upon him, but he held the chair for one year only. The education at West Point is gratuitous, but each cadet is expected to give eight years' service to the Government, unless he be sooner released: Bache served as a Lieutenant in the Corps of Topographical Engineers till 1827, when he was nominated to the Professorship of Natural Philosophy and Chemistry in the University of Pennsylvania. This post he occupied with distinguished success till the year 1836. The College and Asylum for Orphans, founded in Philadelphia by the princely bounty of Stephen Girard, was then springing into activity, and Professor Bache was made its President. Upon taking office he was at once deputed by the Trustees of the College to visit Europe, and inquire into the existing state of education in the schools of Great Britain and the Continent, especially those that bore similarity in objects and character to that under his control. Pursuing this mission, he made a tour through the important scholastic institutions of England and Scotland, France, Switzerland, Holland, Belgium, and the chief States of Germany; making also a rapid visit to Italy. Every detail of instruction and government was examined in the numerous establishments of various classes that came under his inspection, and a large collection was made of text-books, instruments, models, drawings, and all other appliances for teaching that were likely to lend useful aid in fulfilling the wide intentions of the founder of the Girard Orphan School. The results of this inspection were embodied in a full and comprehensive report given to the world in the year 1839, and forming one of the most exhaustive summaries of orphan and general education ever produced, although it embraces but a portion of the materials that were collected for it.

During the Presidency of Professor Bache a Magnetic Observatory was established in connexion with this College, and, in 1840, a system of observations was commenced, in pursuance of the plan recommended by the British Association. Bache gratuitously directed these till his removal from Philadelphia in 1843, and after this he retained general superintendence of them till the series terminated in 1845. During the years 1840–41, he also made a detailed magnetic survey of Pennsylvania and the adjacent parts of New York, Ohio, and Maryland; determining the magnetic declination, dip, and intensity, at a number of stations suitably selected with regard to the course of isomagnetic lines. The discussion of these observations and of those made at Girard College were interrupted by the pressure of subsequent official duties, and were only completed after the lapse of many years.

In 1843 Dr. Bache entered upon that portion of his life's labours which has made his name famous throughout the scientific world. It was in 1807 that Congress passed an act authorising the Survey of the Coasts and Harbours of the United States. Plans of operation were invited from scientific men, and, of thirteen that were offered, one proposed by Mr. F. R. Hassler was accepted, its author being subsequently appointed to superintend the Survey. This he did with great zeal and ability, and the work might have been completed under his direction, but for its interruption for a period of nearly fifteen years, when he was in the prime of manhood and strength. Hassler died in 1843; Bache was at once appointed to succeed him. In entering upon his new duties, he expressed diffidence in his powers to do full justice to a work that his predecessor had created and made so peculiarly his own; but he resolved to apply himself to it with "entire devotion and unwearied energy," to quote his own words. The primary aim of the Coast Survey was to furnish, with the fullest possible accuracy, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and defence of the coast. For the first of these are necessary the fixation of geographical positions by accurate astronomical determinations, the measurement of bases, and primary and secondary triangulations; for the second, minute plane table surveys and contourings; for the third, soundings off the coasts and in the bays, harbours, and other navigable waters connected with the ocean, the charting of shoals, rocks, &c., and the determinations of the direction and velocity of currents. These field operations involve heavy office work, reduction of observations, map-drawing, engraving, and printing. The scientific preparation, the practical knowledge, and the administrative talent, necessary for the successful conduct of operations of such magnitude and complexity could have been found in few men: it is not too much to say that Bache possessed all these requirements. The national work, great and important as it was when he took charge of it, grew in importance under his command. Old instruments and methods were replaced by others embodying modern principles and refinements: foremost among these may be mentioned the electrical determination of longitudes, which was employed between the principal stations of the Survey in 1845, and in many subsequent cases in which the existence of telegraphic communication rendered it possible. As the work progressed additional duties were undertaken; some, as the supervision of lighthouses, buoys, and beacons, imposed by the Government; others, self-imposed. By husbanding the strength at his disposal, Bache, who was a hard worker and genially encouraged hard work in others, widely extended the range of subjects originally embraced by the Survey: he organised magnetic observations, and recorded meteorological data, earthquake phenomena, and, for a time, the appearance of Sun-spots. Although the principal share of his work will go to the furtherance of geographical knowledge, yet astronomy will indirectly benefit by it. Geodesy, too, will be advanced, for the Survey of the Atlantic Coast involves the measurement of an arc of latitude extending over twenty degrees. Terrestrial magnetism will profit by his extensive and systematic observations, and climatology by his comprehensive researches upon the movements of the Gulf Stream. His annual reports to Congress, increasing in extent and fulness as his labours neared completion, embrace an invaluable repertory of physical investigations, while they form a step-by-step history of the progress of a survey as certainly the most accurate as it is obviously the most extensive that has yet been produced or called for by any nation in the world.

Professor Bache contributed many memoirs, embodying the results of original researches in various branches of physical inquiry, to the American scientific journals, chiefly to ***Silliman's Journal***, and the ***Proceedings of the American Association for the Advancement of Science.*** Of this Association he was twice President, and always a leading Member. He was an Associate of the principal learned Societies of Europe. In 1858 the Royal Geographical Society awarded him the Victoria or "Patron's" Medal for his labours in connexion with the Great Survey. When, in 1863, the National Academy of Sciences was established by Act of Congress to represent and direct the highest science of the country, the members of that body unanimously elected him the first President for a period of six years. This period was unhappily cut short. His brain softened, it has been suggested from over-exertion, and, after a long and painful illness, he died at Newport, Rhode Island, on the 17th of February, 1867.

Wherever his name is mentioned it is coupled with expressions of admiration and respect. A high official of his Government said of him that "his genial disposition attracted the love of associates and subordinates: his wisdom commanded their respect. He leaves us a name of unsullied purity, and a memory that adds lustre to the many public records upon which it is borne." J. C.

The REV. HENRY JOSEPH BOONE NICHOLSON, D.D., an honorary Canon of Rochester Cathedral, was the son of the Rev. J. Payer Nicholson, formerly Rector of St. Alban's, to which Incumbency Dr. Nicholson was himself instituted in the year 1835. He was elected a Fellow of this Society in 1825, and was also a Fellow of the Society of Antiquaries and of the Numismatic Society. His attention was chiefly directed to antiquarian pursuits, and his *Handbook to the Abbey of St. Alban's* is a very able work, showing not only his thorough acquaintance with the various styles of architecture exhibited in the building, but a large amount of varied historical research. He died July 27, 1866, at the age of 71, universally regretted.

The REV. MILES BLAND, D.D., F.R.S., was one of the first Fellows of the Astronomical Society. He was born on Oct. 11, 1786, at Sedbergh, in Yorkshire, where his family had resided for many generations. The Blands of Sedbergh appear, from Carlisle's *Collections for a History of the Ancient family of Bland*, to have been the original stock of the family. Carlisle writes (p. 2): "The family of Bland is purely English, and of very high antiquity. . . . Their surname is derived from Bland, or Bland's-Gill, a hamlet in the chapelry of Howgill, and Parish of Sedbergh." And he mentions William de Bland as doing good service to King Edward III. in his wars in France; Thomas de Blande and Robert de Blande as specially included in a proclamation of Sept. 25, 1386, and charged to take care that no arms or horses were sold to the king's enemies from the North Riding of Yorkshire; Patricius de Bland, of Sedbergh (p. 5), as one of some gentlemen appointed in 1333 to raise and command troops for an expedition against the Scots. Of the Sedbergh Blands was (p. 5) John Bland, Rector of Adisham in Kent, who had for a pupil at Adisham Edwin Sandys, afterwards Archbishop of York, and was one of the sufferers in Queen Mary's reign, having been burnt at Canterbury on July 12, 1555.

Miles Bland was educated at Sedbergh School, from which he went to St. John's College, Cambridge, in October 1804. Private tuition at Cambridge was then little known. The great mathematical tutor of the day was Mr. John Dawson, a retired surgeon of Sedbergh, and a self-taught mathematician. Cambridge students went to read with him at Sedbergh in the summer vacations, and sent problems and questions to him from Cambridge for his solutions. Dr. Bland was wont to say that Mr. Dawson had had eleven Senior Wranglers for his pupils, and intended him to be the twelfth; but he was second, in 1808, to Bickersteth, afterwards Lord Langdale. Blomfield, afterwards Bishop of London, was third; and Sedgwick, the present Professor of Geology at Cambridge, and Bland's schoolfellow at Sedbergh, was fifth. Bland was elected Fellow of his College in 1808, and in 1809 was appointed Assistant Tutor, and continued in the tuition, first as Assistant Tutor, and afterwards as joint tutor with Mr. Hornbuckle, till 1823, when he took the College living of Lilley in Hertfordshire, and married. He was very highly appreciated by his pupils as a lecturer, and not less as a friend and adviser. He resided at Lilley till failing health obliged him to seek change of climate at Ramsgate. After some years he returned to Lilley, and resided there for thirteen years: but he was obliged again to leave it in 1852, and resided at Ramsgate ever after. He never held any other preferment than his living, except a prebend at Wells, little more than honorary. He was a Fellow of the Royal Society, and of the Antiquarian Society, and a member of the Royal Society of Literature. He published a collection of Geometrical Problems, with an Appendix on Plane Trigonometry, a Treatise on Hydrostatics, Mechanical Problems, Problems in the different branches of Philosophy, and Algebraical Problems, better known as *Bland's Equations*, which have exercised the ingenuity of many a young mathematician. This last publication passed through many editions. A translation of it was published at Halle so recently as 1857. He drew up also Annotations on the Historical Books of the New Testament, but did not proceed with the publication of them beyond the Gospels of St. Matthew and St. Mark. His vigour of mind and keen interest in everything that passed, and particularly in all that affected his University and his College, he retained to the end of his life. He died of old age, without disease and without suffering, on Dec. 27, 1867, at the age of 81 years.

James John Downes, Esq., was born of humble parentage, on October 18, 1790. With indomitable energy he succeeded in qualifying himself for the position of mathematical tutor and lecturer on science. Among his pupils were several who afterwards obtained considerable reputation as mathematicians, while his originality of thought and skill in demonstration procured for him celebrity as a lecturer. In 1832 he was elected, after a strict examination, from upwards of thirty candidates, to fill the office of Actuary to the Economic Life Assurance Society. He performed the duties of this office with much ability and zeal for a period of thirty years, when he retired into private life, carrying with him the esteem and respect of all with whom he had been officially associated. He died on November 12, 1867, beloved and respected by a wide circle of friends. He was a Member of the old Mathematical Society, and for some time officiated as Secretary. He published a small Handbook of Algebra, which is now out of print. He became a Fellow of our Society in 1837, and took an active part in the transfer of the old Mathematical Society and its valuable library to the Royal Astronomical Society.

Charles Howell, Esq., died at Hove, near Brighton, on December 8th, 1867, aged 84 years. He was elected a Fellow of our Society in 1857. He inherited from his father an ample fortune and devoted his early life, with much zeal, to nautical and agricultural pursuits. He was always attached to the use of the telescope, but it was not till he was far advanced in life that he built an observatory, furnished with excellent instruments, at Hove.

Mr. Howell's astronomical observations were chiefly of planets and of double stars. When by reason of advancing years he had become unfitted to employ himself in his observatory, he generously opened it to the unrestricted use of his numerous friends, and also for the purposes of education, in the hope thereby to enkindle in youthful minds a love of that science which he so ardently admired.

One of his last acts was to erect upon a valuable piece of ground in the centre of Brighton a range of almshouses which he has bequeathed for the use of the poor of that town. He died universally respected, and the poor deplore the loss of a truly benevolent and tender-hearted man.

Mr. **William Brooke** was born at Burnham Market, in Norfolk, on August 1st, 1795. His education at the outset was such as in remote provincial towns in those days was the only one accessible to the middle classes. But he was from his earliest years studious, and qualified himself to enter a private school kept by a Mr. Shrimshire, the Incumbent of North Creek, where he devoted himself to classical reading with so much assiduity as in a large degree to make up for his want of a public-school training. About the year 1820 he opened a school at Norwich, which he continued until age made it needful for him to retire from an occupation in which he had been engaged with much honour and a fair share of success for about forty-five years. Not a few of his pupils have acknowledged with gratitude the benefit they derived from his lectures on Experimental Science. This was before the appointment of Professor Sedgwick as Canon of the Cathedral, and the elevation of Bishop Stanley to the See of Norwich. These events greatly stimulated the scientific activity of the city, and Mr. Brooke was soon found in the front ranks of a considerable and energetic band of inquirers and observers,—a position which he maintained to the end of his life. His meteorological observations were commenced before 1830; the records he kept and supplied to the local papers and to scientific journals. Mr. Brooke was elected a Fellow of our Society in 1849. In 1850 he joined the Meteorological Society. He died upon his natal day in 1867, aged 72 years, leaving behind him, in a wide circle of friends, the memory of a blameless and well-spent life.

PROCEEDINGS OF VARIOUS OBSERVATORIES.

Royal Observatory, Greenwich.

The work of the past year has been of the usual character: comprising observations of the Sun, Moon, and principal planets, at every opportunity on the meridian; observations of the Moon with the Altazimuth extended as near conjunction as possible; and continuous observation of the principal stars.

The re-observation of Bradley's Stars contained in Bessel's *Fundamenta* has been completed, and it is intended to incorporate in a catalogue the results of the star-observations from 1861 to 1867 inclusive.

For the reduction of the Observations in 1868, the refractions will be computed with the mean refractions of Bessel's *Fundamenta* diminished in the proportion of

$$0{\cdot}99797 : 1$$

combined with the meteorological corrections of the *Tabulæ Regiomontanæ*. The colatitude adopted is 38° 31′ 21″·60. These changes have been made on the authority of Mr. Stone's paper in the *Monthly Notices* for Dec. 13th.

The piercing of the central cube of the Transit-Circle to allow of the adjustment of the wires of the collimating telescopes without raising the Transit-Circle has been followed by a change in sign of the astronomical flexure of the telescope. It has been found that the sign of the law of discordance between the direct and reflexion observations has changed, in 1866, with the change of sign in the astronomical flexure of the telescope; the resulting value of the colatitude is in satisfactory agreement with values previously obtained. It is probable that this will throw considerable light upon the origin of the discordances between the observations of stars in zenith distance directly and by reflexion at the surface of quicksilver.

The middle room of the Great Equatorial Dome has been rendered fire-proof and will be used as a room for the deposit and trial of chronometers.

The greater part of the volume for 1866 has been passed through the press, and the reductions of the Observations for 1867 are complete and the results nearly ready for the printer.

Royal Observatory, Edinburgh.

The work performed here during the past year has not materially deviated from the usual Star Observations with the Transit Instrument and Mural Circle; public time-signals, with electric controlled clock superintendence; and the computations of meteorological observations from fifty-five observing stations of the Scottish Meteorological Society, the results being printed and published monthly or quarterly by the Registrar-General of Births, Deaths, &c. in Scotland. None of the additional accommodation so urgently required for the performance of this work has yet been supplied; and there is now a negotiation in progress for giving to the Royal Observatory, Edinburgh, the observations of seventeen more meteorological stations to compute every month, making seventy-two of such stations in all.

Radcliffe Observatory.

The subjects of observation at the Radcliffe Observatory, Oxford, were essentially the same for the past year as for those immediately preceding. The star-list includes the stars necessary for the completion of the re-observation of those which require it in the Catalogue of the British Association, and stars between the sixth and eighth magnitudes, lying chiefly between 50° and 70° of North Polar Distance, selected from various Catalogues. The Sun, as in former years, has been observed whenever it has been practicable, though the state of the sky has been, on the whole, nearly as bad as in the year 1866. The Moon has been observed in each lunation till the first transit (inclusive) after opposition; and *Mercury* and *Mars* whenever it has been practicable. The number of stars observed generally in both elements in 1867 is 1453; while, of the Sun, 92 observations have been made, of the Moon 56 observations, of *Mercury* 34, and of *Mars* 17 observations. The whole number of transits amounts to 2472, and of North Polar Distances to 2314. The number of good evenings for observation was, as in the year 1866, small.

The heliometer has been employed by Mr. Main, as in preceding years, for the observation of double stars. In connexion with this instrument it may be mentioned that, after a little correspondence with Mr. Merz, the maker of the object-glass, Mr. Main succeeded in separating the crown and flint lenses of the segments of the object-glass, and, after cleaning their inner surfaces carefully, in fastening them together again, without detriment to the goodness of the images. Some additional transits of circumpolar stars were taken in the autumn, during some hot weather, for the re-determination of the value of the screw, by which it appears that that which has been in use for several years is sensibly accurate.

The reductions of the astronomical observations have been kept up with the same rigour as in the preceding years. The transits were perfectly reduced and ready for transcription into the ledgers, at the close of the year, and the North Polar Distances are now nearly completed. As in former years this has entailed very heavy personal labours on the Director.

The beginning of the solar eclipse of 1867, March 5–6, was well observed by three observers; the observation of the termination was prevented by clouds. A few observations of occultations of stars have also been made.

The printing of the Astronomical Results of observations for 1865 has been completed for some time, and copies were sent to a few of the chief astronomers in Great Britain; the printing of the Astronomical Results for 1866 is proceeding steadily.

The Meteorological reductions are, as in the preceding years, considerably in arrear, those for 1865 being not nearly completed. Their utility is, however, such, that the Director is unwilling to give up, for the present, at least, any of the discussions which have been carried out in former years.

Recently Mr. Baxendell has made some interesting deductions from the observations of solar radiation, by which it appears extremely probable that there is a periodicity of solar radiation synchronizing with the periodicity of the solar spots. Mr. Baxendell's discussions will at least give a value to observations of solar radiation which did not appear to belong to them before, and probably induce private observers to bestow greater care and attention on them.

In addition to the ordinary labours of the Observatory which have been detailed, a great deal of work has been done during the past year towards the compilation of the *Second Radcliffe Catalogue of Stars*. This is now in a very forward state. The results for the different years have been all combined in one catalogue, and reduced to the proposed epoch 1860; and the annual precessions and secular variations for that epoch have been computed. The Catalogue itself has been formed, containing very nearly 2400 stars (observed between 1855 and 1861, both inclusive), and the precessions and secular variations are transcribed into it. Very little remains to be done, but the combination of the observations in the different years, and the application of the corrections which may be considered necessary, as the result of the discussions which are connected with the work. It is expected that the Catalogue will be printed and published in the course of the present year.

Cambridge Observatory.

In addition to the ordinary transit and circle observations, the accurate determination of the places of those stars, selected from Oeltzen's List, in which the comparison of Lalande and Argelander seems to indicate large proper motion, has been constantly kept in view. These observations are now all but completed, and great progress has been made in the reductions. The true apparent right ascensions are obtained to May, 1867, and the true North Polar distances to the end of 1866. The reductions to the mean place for the beginning of the year are calculated to the end of 1866.

The equations of condition from occultations of fixed stars by the Moon, are calculated to the end of 1866, and equatorial observations of Comets are nearly all reduced.

The copy for the press is in progress, and will very shortly be in a sufficiently advanced state to be put into the hands of the printer.

The velocity of the wind has been measured by the Robinson's anemometer, which has worked satisfactorily, and a new and very sensitive vane has been erected.

All the meteorological observations have been regularly taken at the hours of 9 A.M., and 3 P.M., and more frequently in heavy storms.

A watch was kept for the November meteors, but the night was unfavourable, and very few were observed.

A small universal instrument, of beautiful workmanship, by Ertel of Munich, the property of the late Mr. Cooper, of Markree, has been secured for this Observatory.

Mr. Simms has made great progress in the construction of a new meridian circle for this Observatory, which is to be erected in the place of the present transit instrument. The circle is three feet in diameter, and the telescope is eight inches in aperture, and about nine feet in focal length. An excellent object-glass by Mr. Cooke, which has been already thoroughly tested by Mr. Dawes, has been purchased for it. The cost of the instrument is to be defrayed out of the Special Fund presented to the University by Miss Sheepshanks for the benefit of the Observatory.

The New Liverpool Observatory, Bidston, Birkenhead.

During the early part of last year the difference of longitude between the old Observatory on the east and the new Observatory on the west side of the Mersey, was found by the transmission of sixty chronometers to be $17^{s}\cdot04$. From this determination the longitude of the new Observatory is $12^{m}\ 17^{s}\cdot15$ West of Greenwich. In remounting the transit instrument of five feet focal length and four inches aperture, provision has been made for using it either in the meridian or in the prime vertical. From five transits of β *Draconis*, four of γ *Draconis*, and one of α *Cygni*, each of them over the east and west prime verticals, the latitude is 53° 24′ 3″·8 N. or 44″·0 South of the old Observatory. By ten simultaneous readings of barometers at the two stations the height of the cistern of the standard at the new Observatory is 212 feet above the mean level of the sea, and 175 feet higher than it was at the old Observatory. The mean temperature for the year is 1°·4 lower at the new than at the old Observatory, as obtained from simultaneous daily readings of thermometers at the two stations during two years. The equatorial of twelve feet focal length and eight and a half inches aperture has been re-erected by Messrs. Troughton and Simms, under a dome of twenty feet diameter. The old transit-clock is placed in a cellar, twenty-four feet below the ground-floor of the building, and clocks controlled by it are placed in the transit and equatorial rooms. A new clock and spring-governor chronograph, made by Messrs. Bond and Son, of Boston, U.S., have recently been erected in a room contiguous to the transit and equatorial rooms. A clock regulated to Greenwich mean time, placed in the chronometer-room, controls one clock in the deep underground cellar, and another on the margin of the river near the Birkenhead Landing-stage; the latter controlled seconds clock, the face of which is exposed to public view, fires a time-gun daily at 1 P.M. An observer in the chronometer-room, within hearing of the beat of the normal clock, never fails to see the flash of the gun on a clear day, and in foggy weather, when the flash cannot be seen, the sound is heard at twelve seconds after 1 P.M. within a small fraction of a second. This mode of communicating time to the port and towns of Liverpool and Birkenhead is already very highly appreciated. The contact springs for the transmission of galvanic currents applied by Messrs. Ritchie and Son, of Edinburgh, to the sidereal and mean time clocks have not affected the regularity of their performance; the rates of both clocks have been much more uniform than they were at the old Observatory; but, in all probability, this is mainly due to their being placed in rooms in which the change of temperature during the year is very small. At the old Observatory, chronometers could only be tested during six or seven months of the year through the range of temperature to which merchant ships are generally exposed; in the new Observatory, during the past twelve months, the chronometers have been exposed on alternate weeks to the temperatures of 55°, 70°, 85°, 70°, and 55°, in regular succession throughout the year, so that in five weeks a chronometer can now be tested efficiently at any time of the year. The Observatory will in a short time be supplied with the means of testing various other nautical instruments in addition to chronometers.

Glasgow Observatory.

At the Glasgow Observatory the astronomical observations during the past year have been similar in character to those of previous years. The Transit Circle has been regularly employed in the observation of a select number of stars chiefly comprised between the fifth and eighth magnitudes. The Ochtertyre Equatorial continues to be used on every available occasion for the measurement of double stars. Correct time is transmitted to the City and Port of Glasgow, as in former years, by means of Jones's well-tried invention of the controlling of clocks by electricity.

The meteorological operations at the Observatory have acquired an important extension since the date of the last Report of the Council. It is generally known that the Board of Trade has recently assigned the superintendence of the meteorological operations of that department to a Committee of men of science, at the head of which is the President of the Royal Society, and that, among other recommendations of the Committee, has been the establishment of a definite number of stations distributed over the British Isles, furnished with self-recording instruments for ascertaining the continuous variations of the weather, and more especially for obtaining an exact determination of the facts connected with the occurrence of storms.

The Glasgow Observatory having been one of the stations nominated for this purpose, has been recently furnished with a complete system of self-recording instruments, the operations with which commenced on January 1 of the present year. It is hardly necessary to state that the Government has undertaken to defray the expenses connected with the fitting up of the instruments and the conducting of the subsequent operations.

Kew Observatory.

The regular progress of the work of the Kew Photoheliograph has somewhat suffered this year from two causes; one being the unfavourable state of the weather, which not only diminished considerably the opportunities for taking photograms, but also interfered with the usually excellent definition of the details in the Sun's appearance. The other cause was the interruption of the work from August 9 to September 9, in consequence of necessary repairs to the dome of the Observatory. There was therefore a falling off in the number of observed groups as compared with those registered by Hofrath Schwabe, by five groups, of which three must be accounted for by the difference of climate, while two groups have been observed in Dessau during the total interruption of the work at Kew. On the whole, there were 130 days of observation, on which 188 Sun-pictures were taken.

The work of reducing the observations, however, has not only been carried on with the greatest vigour, but former investigations have been extended on the basis of the Kew photograms, and steps have been taken to arrive at trustworthy results with reference to the important question of the influence of optical distortion on the observation-elements supplied by celestial photography generally and the Kew Photoheliograph specially.

The authors of the *Researches on Solar Physics*, Messrs. Warren De La Rue, Balfour Stewart, and Benjamin Loewy, announce that the third series of these is completed, and will probably be ready for the printer in a few weeks. They give in this paper, to which about 100 pages of tables are added, the following information:—

1st. A full description of the methods employed in the measurement and reduction of solar photograms, for determining the heliographical longitude and latitude of Sun-spots, with the view of deducing from them the elements of rotation of the Sun and the inclination of the solar equator to the plane of the ecliptic; also the final results, giving the heliographical elements of all Sun-spots observed in 1862 and 1863. This part may in a measure be regarded as a continuation of Mr. Carrington's results.

2nd. The results of the area measurement of all Sun-spots observed in 1862 and 1863, forming a continuation of their results published in Series II. of the *Researches*, which were founded on Mr. Carrington's drawings.

3rd. An account of some preliminary experiments undertaken to determine the amount of optical distortion in the photograms obtained with the Kew Photoheliograph.

4th. An inquiry into the distribution of spots in latitude, extending their former researches, which had only the ecliptical longitude in view, and adducing additional evidence for attributing to the planet *Venus* a preponderant influence on solar activity.

The plan for the work of the present year comprises the continuation of the astronomical work and application of the results to a new determination of the solar elements; area measurements of all Hofrath Schwabe's Sun-pictures, for establishing a more trustworthy curve of periodicity; the extension of their researches into the physical phenomena on the Sun based on these results; a repetition of the investigations on the distortion of the photographic image with more refined methods; and, finally, hopes are entertained that regular observations of the heating and actinic effects of the Sun may be set on foot.

Lord Rosse's Observatory.

The most remarkable amongst the recent observations made at Birr Castle is the discovery in four nebulæ of a more or less marked spiral arrangement.

These nebulæ are indicated by the following numbers in Sir John Herschel's General Catalogue: —

$\left.\begin{matrix}1519\\1520\end{matrix}\right\}$ Double Nebula, $\left.\begin{matrix}385\\386\end{matrix}\right\}$ Double Nebula, 1596, 2708

As the work on the Great Nebula in *Orion* was allowed to take precedence of other work, fewer observations on the nebulæ generally were made during the last year than would have been made under other circumstances; but from September 1866 to April 1867 more than 300 observations were recorded.

When the clock movement for the great reflector, which is now in progress, is finished, Lord Rosse intends to make further spectroscopic observations, and to try lunar photography, which was attempted, though with little success, some years ago, when the art was in a less perfect state.

Mr. De La Rue's Observatory at Cranford.

The past year has been remarkably unpropitious for the work carried on at this Observatory, for not only has the sky been overcast for a greater number of days than usual, but also the atmosphere has been very much disturbed on most occasions when astronomical photography could be attempted. This state of things has caused considerable perplexity, because two astronomers desirous of obtaining instruction in astronomical photography have had very considerable difficulty in obtaining the requisite opportunities for so doing. Mr. Le Sueur stayed at Cranford for some time during the month of February, and, by dint of great perseverance and watching for opportunities, was enabled to make lunar photographs on several occasions, and to thoroughly familiarise himself with the operations of astronomical photography. Notably on Feb. 22, Mr. Le Sueur, aided by Mr. Reynolds (photographic and mechanical assistant at Cranford), obtained a photograph of the Moon, of remarkable sharpness. Mr. Le Sueur, it is known, will have charge of the great Melbourne Telescope, which has been made by Mr. Grubb of Dublin, under the superintendence of the late Lord Rosse, Dr. Robinson, and Mr. De La Rue. Major Tennant, who will conduct the observations of the total solar eclipse in India on August 18th, which have been promoted by our Society, has also received instruction at Cranford, where he resided for some days on three occasions. On the first occasion, he was unable to obtain any opportunity for photography; in September, however, he was more fortunate, and took part on the 13th of that month in the photographic records of the lunar eclipse which occurred on that day. In December, Major Tennant was accompanied by the Sappers who had been detailed for the eclipse operations in India. The party consisted of Sergeant-Major Phillips and two Sappers. They thoroughly familiarised themselves with the working of the equatorial and the details of the photographic operations performed with it; they also received instruction in enlarging photographs, and in etching them on glass, as detailed in Mr. De La Rue's Bakerian Lecture on the Solar Eclipse of 1860, published in the *Philosophical Transactions* for 1862. Major Tennant and his party therefore start with all the experience which has accrued from Mr. De La Rue's work in 1860–61; and if the weather prove propitious, it may fairly be expected that valuable records will be obtained by him and his staff.

Mr. De La Rue has received two silvered-glass mirrors from Mr. With; the first, although very good, was not considered by him to be equal to the metal mirrors figured by himself. The second, which has only been recently received, Mr. With believes to be very superior to the first made by him for the Cranford Observatory: but the weather has not yet permitted a fair testing of its performance.

Mr. De La Rue intends taking up again experiments in the figuring of specula; for which object his polishing machine has been removed from London to Cranford, where a small steam-engine has been erected. Hitherto, the polisher has been circular, and of nearly the same diameter as the speculum to be polished; it is evident, however, that a convex paraboloid of revolution can only fit exactly in a concave paraboloid so long as their axes coincide, which can only occur rarely during the operation of polishing. Three points, however, would touch a concave paraboloid in any part of the curve; although three mere points could not be used as a polisher, three small disks of pitch may be so employed, and it is assumed that by the use of a polisher so constructed, better figures may be obtained than heretofore:—it is in this direction that Mr. De La Rue's operations will be conducted.

Mr. Huggins' Observatory.

From the results of *spectroscopic* research at this Observatory during the past year, the following observations may be selected for mention.

The spectrum of *Mars* was carefully re-examined, but as this investigation has appeared in the *Notices* of the Society, it is not needful to give any details here.

On December 5, Mr. Huggins subjected the spectrum of the planet *Neptune* to a careful scrutiny, but was unable to detect any unusual lines of absorption which might account for the strongly marked blue colour of this planet. The faintness of its spectrum does not permit any great value to be attached to this negative result.

The comets visible during the year were too feeble in brightness to admit of the successful application of the prism. On two occasions, however, the spectrum of Comet II. was believed to be similar to that of Comet I. 1866.

The spectra of the stars ν and μ *Geminorum* were examined in April. They were found to resemble very closely that of α *Orionis*, though there is apparently a somewhat different relative intensity of the lines.

During June, the spectrum of α *Herculis* was carefully examined, and the remarkably arranged groups of lines were remeasured. These observations agree with the measures and comparisons of the chemical elements of this star obtained in 1863.

Mira Ceti, which gives a spectrum apparently identical, or nearly so, with α *Orionis*, was examined when at its maximum brilliancy, and on several subsequent occasions, after it had commenced its downward curve. At the time the star was waning in brightness there was an appearance of greater intensity in several of the groups, but a continued series of observations is desirable, before any opinion is hazarded as to the cause of the variation in brightness which has procured for this object the title of "Wonderful." At Mr. Baxendell's request the variable R *Coronæ* was examined when at its maximum in the autumn, but without any successful result.

Mr. Huggins has confirmed the observations of MM. Wolf and Rayet so far as to the presence of bright lines in the three small stars described by them. He has not determined the number and positions of these lines.

During the year several attempts have been made to obtain a useful spectrum of the Milky Way. The spectra of the minute stars which are separately visible in his telescope were all continuous, but the spectra of unresolved portions could not be determined with certainty. There appears to be great probability, from their faintness, that these spectra are also continuous, for if they had consisted of a few bright lines, they would probably have been of manageable brightness.

The lunar object, *Linné*, has been observed and measured on every favourable opportunity during the year. The results obtained up to June are contained in the *Monthly Notices* for that month. Numerous observations have been obtained since, but Mr. Huggins is not prepared to make any further statement at present.

A few occasions of unusual atmospheric clearness were employed to re-examine and measure the bright granules of the solar surface. These views and measures confirm in every particular Mr. Huggins' description of these bodies in the *Notices* for May 1866.

Mr. Huggins has succeeded in constructing a new spectroscope, by which he is enabled to bring to bear on the celestial bodies an amount of dispersive power several times greater than has hitherto been applied to them. In this instrument the prisms employed have a dispersive power equal to about seven prisms of dense flint-glass of 60°. This instrument is found to be quite manageable even upon the nebulæ, and with it the bright lines of the Great Nebula in *Orion* and of some other nebulæ have been compared directly with the bright lines of terrestrial elements.

Mr. Huggins intends to make use of this instrument in the continuation of his observations on the spectra of different parts of the Sun's surface, and of the solar spots. He has already insulated the spectrum of the umbra of a spot. These observations are in progress.

During the last two years Mr. Huggins has made numerous observations for the purpose of obtaining a view, if possible, of the red prominences seen during a solar eclipse. The invisibility of these objects at ordinary times is supposed to arise from the illumination of our atmosphere. If these bodies are gaseous, their spectra would consist of bright lines. With a powerful spectroscope the light reflected from our atmosphere near the Sun's edge would be greatly reduced in intensity by the dispersion of the prisms, while the bright lines of the prominences, if such be present, would remain, but little diminished in brilliancy. This principle has been carried out by various forms of prismatic apparatus, and also by other contrivances, but hitherto, however, without success.

THE PROGRESS OF ASTRONOMY DURING THE PAST YEAR.

We have not, as on some former occasions, to record any remarkable and salient discoveries which will make the past year memorable in the annals of the science of Astronomy; but still, in the great activity which has been displayed by the cultivators of all its branches, we may see bright indications of sure and steady progress. Some of the labour of the past year has been spent in the form of preparation, the fruits of which, it is to be expected, will enrich the roll of discovery and research of the present and many succeeding years. Expeditions furnished with elaborate instruments have been originated and sent on their way to a distant country, for the purpose of learning as much as possible from the phenomena of a remarkable solar eclipse. Rapid progress has been made towards the completion of two magnificent telescopes, both of which will probably leave our shores during the present year.

We proceed to notice these and some other matters of prominent interest to the science of Astronomy.

The Total Solar Eclipse of August 17, 1868.

The present year will be signalised by a total solar eclipse of almost the greatest possible duration. As probably centuries may elapse before we shall have again an opportunity so exceptionably favourable for observing the peculiar phenomena which are only to be seen during a total eclipse of the Sun, it will be a source of gratification to the Fellows of the Society that two well-equipped expeditions have already proceeded to India for the purpose of making observations during the eclipse of August next.

One of these expeditions was originated by our Society.

Two letters of Major Tennant's, one published in the *Notices* of this Society for January, 1867, and the other forwarded to our Secretary early in February, but (owing to the Annual Meeting) only published in March, drew attention to the remarkable Total Eclipse of August 18, 1868. At their Meeting in March the Council accordingly appointed a Committee, consisting of the President, the Astronomer Royal, Mr. De La Rue, Maj.-Gen. Shortrede, and Col. Strange, to forward, if possible, the object of making observations during the very long obscuration of the Sun. It was decided that an application should be made to the India Office to bear the expenses of establishment and instrumental means, and that a silvered glass mirror should be mounted equatorially for photography, and that two telescopes kindly lent by the Astronomer Royal should be fitted for spectroscopic and polarization experiments. Estimates were submitted for the cost of instruments through the Astronomer Royal, and on the 15th July, sanction having been received for the cost, the instruments were ordered. Major Tennant proposed that he should be aided by Capt. Branfill, of the Great Trigonometrical Survey, and Lieut. Herschel, R.E., of the same department (who, however, has since undertaken a commission from the Royal Society), and that three men of the Royal Engineers should be trained to carry out the photographic operations. After some considerable delay, the expense was sanctioned, the Treasury having consented to bear half the amount. The delay had expended Major Tennant's leave of absence from India, and as much remained to be done, he was, on the matter being represented to the Secretary of State for India, detained at home on duty to superintend the preparations and the instruction of operators. Before proposing officially to employ men from the Royal Engineers, Major Tennant believed he had satisfactorily ascertained that there would be no difficulty as to their services being available; but an unexpected one arose, and it was fortunate that he was on the spot to remove them. He was cordially aided at the India Office by Mr. Arthur Hobhouse, who throughout has taken a personal interest in these observations, and assisted in every way to remove obstructions and avoid delays. On the 10th December Sergeant Phillips and Sappers Talbot and Conway, of the Royal Engineers, went to Cranford, where, by Mr. De La Rue's kindness, they went through the whole of the processes of taking the small negatives, enlarging, and etching them on glass. Major Tennant had gained some previous experience from several visits at Cranford since April last, and, though unfortunate generally in the weather, he had assisted at photographing the lunar eclipse on Sept. 13. The proposed photographic operations differ from those formerly undertaken by Mr. De La Rue in Spain, where the Kew Photoheliograph was used, and the image of the Sun, in the focus of the object-glass, was enlarged by a suitable eye-piece before falling on the sensitive plate. It is now proposed to use a reflecting telescope (which ensures absolute identity of the actinic and visual foci) and to place the plate in the principal focus of the great speculum. The form is Newtonian, and the image being taken at the side of the tube allows room for a larger plate than could be placed in the centre of the tube; this is of great importance, as it is desirable to obtain as much of the corona as possible. The whole has been constructed by Mr. Browning, who has devoted to it a very great amount of time and care, with the advantage of the advice and experience of Mr. De La Rue. It is very satisfactory to know that the process of photographing celestial phenomena has been so completely mastered by Mr. De La Rue, that ordinary photographers can be taught in a few hours to use his apparatus with success.

In a paper printed in the Supplementary Number of our *Notices* Major Tennant, in view of his then immediate departure for India, described the apparatus which was in preparation. On Nov. 9, the Council were enabled, through the kindness of Mr. Howlett (who waved his claim on the instrument) to lend the Sheepshanks Telescope, No. 3, and by a grant from our funds to have it so modified as to enable this instrument to be used in the low latitude in which the eclipse is visible as total. Major Tennant, having thus an equatorial with clockwork motion, has transferred to it the spectroscope made by Mr. Simms, and has adapted the polarization apparatus made by Mr. Ladd to the telescope from Greenwich, which was equatorially mounted by Mr. Simms for the spectroscope, as described in the paper referred to. The facilities for observing have, of course, been thus greatly increased. In the arrangement of the spectroscopic and polarization apparatus, Major Tennant desires to acknowledge the aid he has received from the Astronomer Royal and our Secretary, Mr. Huggins.

The other expedition has been sent out by the Royal Society, and the necessary instruments provided out of the Parliamentary grant annually placed at the disposal of that Society.

The superintendent of this expedition, Lieut. John Herschel, R.E., an assistant in the Great Trigonometrical Survey, and a son of Sir John Herschel, has been instructed to confine his attention to observations of the spectra of the corona and red prominences, and to an examination of the light of these objects for polarization. He is provided with instruments suitable for these observations. The telescope for the spectrum observations has an aperture of five inches, and an equatorial mounting. It is furnished with a superior driving clock, the rate of which is maintained uniform by a form of pendulum-governor recently invented by Messrs.

Cooke and Sons, by whom the whole instrument was constructed. It is provided with a complete spectroscope constructed by Messrs. Simms.

For the observations for polarized light there is a second telescope of three inches aperture, furnished with two analyzers. The observer is instructed to use, first, a double-image prism, and a plate of quartz cut perpendicularly to the axis. If only a small amount of polarised light be present, it will be shown by the complimentary tints of the images. The second analyzer, consisting of a Nicol's prism and a compound plate of quartz, showing Savart's bands, may then possibly be employed with advantage to determine the position of the plane in which the light is polarized.

In addition to these instruments, four hand spectrum-telescopes of the form constructed by Mr. Huggins for the observation of meteors,* have been sent out for use by observers stationed at different places along the central line of the eclipse.

It will be, doubtless, of interest to our Society to know that Lieut. Herschel has been recommended to apply himself, as far as his other arrangements may permit, after his arrival in India, until the period of the eclipse, to the extremely important work of a prismatic examination of the brightest of the Southern Nebulæ. For these observations the instruments at his disposal are perfectly suitable.

Unless the weather should be unfavourable at both the stations selected by the two expeditions, we may confidently anticipate results of great value to our knowledge of solar physics from the carefully considered observations which are proposed to be made in August next.

This may be a suitable place to call attention to an observation of a red prominence made during the annular eclipse of March 6, 1867. Dr. Weiss, who accompanied an expedition into Dalmatia, where the eclipse was annular, has placed on record the following observation of Ensign Kiha, who was stationed about 2½ geographical miles north-west of Ragusa. He made use of a telescope of 2-inches aperture, furnished with an eye-piece magnifying 40 diameters. 14·4 minutes before the annulus was formed he saw a protuberance which, with some interruptions from clouds, he kept in view until 14·7 minutes after the formation of the ring. When first detected, the prominence was already a striking object, and it disappeared, not through excessive faintness, but in consequence of the passage of a cloud. Kiha described the object to be of the form of a small flame, and to have a brownish yellow colour. It was marked in the direction of its length by stripes of a deeper tint of the same colour. The observations of the protuberance show that it could not have had any connexion with the Moon.

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* See "Proceedings, Royal Society," vol. xvi., p. 241.

It is certainly important that these phenomena should be looked for on every occasion which may possibly favour their visibility.

On the Possible Influence of the Tides on the Position of the Earth's Axis.

The question, so highly important under many aspects, of the possible effects during the past history of the Earth of the frictional action connected with the tides, has been carefully discussed by Mr. Stone, in reference to the possibility of the production by this action of a secular change in the position of the Earth's axis of rotation. Mr. Stone investigates this action upon two distinct hypotheses. He first takes the frictional action to be equivalent to a couple whose intensity is proportional to the existing angular velocity, and whose axis coincides with the instantaneous axis. Secondly, he supposes that the tidal action may be represented by a couple of resistance with its axis perpendicular to the plane of the ecliptic and proportional to the relative angular velocity of the Earth and Moon on this plane. The exceeding slowness of the resulting secular changes would appear to remove the tidal action from the direct causes to which we may look for those great secular changes of climate which geology has shown to have succeeded each other upon the surface of the Earth.

Star Catalogues.

The observations of stars made with the Meridian Circle of the Bonn Observatory from the year 1845 to the beginning of the year 1867, have been collected by Dr. Argelander into a catalogue, the epoch of which is 1855. This valuable Catalogue contains accurate places of most of the known variables. The total number of star places contained in the Catalogue is 33811.

Mr. Ellery, the Director of the Melbourne Observatory, has published his star observations made during the year 1863, 1864, and 1865. These observations are of great importance in the present dearth of materials from the Southern hemisphere. Mr. Ellery has most wisely extended his observations of Circumpolar Stars to considerable distances from the pole, and has also observed a large number of stars for comparison with the results of the Northern observatories.

Manuscript Star Charts.

During the past year the Society has become possessed of a very valuable series of MS. Star-charts by presentation from Sir John Herschel.

These charts contain the estimated magnitudes of stars visible to the naked eye in both hemispheres, and were made by Sir

John Herschel both at the Cape of Good Hope and in England. These charts have been strongly bound in volumes. They will be of great value in the case of any suspected changes of magnitude, and especially in the event of a supposed disappearance or outburst of a star.

Spectrum Analysis.

During the past year the most important addition which our science has received from the application of spectrum analysis to the heavens has been obtained at the Paris Observatory. After an extended examination of stellar spectra with the large silvered glass reflector belonging to that Observatory, MM. Wolf and Rayet at length discovered three stars, at no great angular distance from each other, which are distinguished by ***bright*** lines in their spectra.

These stars are, in Argelander's Catalogue (1850):—

Zone	+35°	8·5 mag.	R.A. 20h	4m	49·3s	δ	+35° 45'·1
,,	+35	8 ,,	,, 20	6	27·3	δ	+35 46·1
,,	+36	8 ,,	,, 20	9	6·7	δ	+36 13·3

In the spectrum of the second of these stars, MM. Wolf and Rayet have observed four bright lines. The brightest of these lines occurs between F and G. The remaining three lines are seen in the part of the spectrum from F to D.

It may be well to suggest that these stars should be carefully watched for variability, as the presence of bright lines may possibly indicate physical conditions existing in these distant bodies, which are possibly of a less permanent character than are those of the stars which possess dark lines of absorption only in their spectra. It is satisfactory to know that Mr. Baxendell has made careful comparisons of these three stars with neighbouring stars, so that if any change of brightness should take place in any of them, it will be readily detected.

Comet II. 1867, has been examined by Mr. Huggins, who concludes, from a somewhat imperfect observation of this faint object, that this small Comet was, at the time of examination, similar in physical constitution to Comet I. 1866.

Mr. Huggins has communicated to the Society, in the *Notices* for March, the results of a further examination of the spectrum of ***Mars.*** In this paper he gives a more detailed account of the lines which show the existence of an atmosphere similar to that of the Earth, though probably not identical with it. Further, he states reasons for attributing the distinctive ruddy colour of this planet not to the absorptive properties of its atmosphere, but to some peculiarity of certain parts of its surface.

Father Secchi has collected in one memoir all the spectrum observations made at the Roman Observatory. The results of these observations have already been published from time to time in the *Comptes Rendus* and elsewhere. This memoir is printed in the *Volumi dell' Academia dei XL*.

The Great Nebula in Orion.

The discovery of the gaseous constitution of many of the Nebulæ, at the same time that it added to the mystery connected with these objects, gave us fresh hope of acquiring ultimately some knowledge of the relation which they hold to the other objects in the heavens. Changes in their appearance, sufficiently marked to be seen by us, and occurring within periods not so prolonged as to make us despair of being witnesses of them, were suggested to us as highly probable. In the northern hemisphere no nebula presents to an observer so large an amount of detailed structure as the Great Nebula in *Orion*. It will therefore be a source of much satisfaction to Astronomers that the results of the study of this object for many years by the late Lord Rosse are now made public by our fellow, the present Earl of Rosse. A large and exceedingly valuable map of the nebula accompanies his paper, which is printed in the *Philosophical Transactions of the Royal Society*.

The materials at our disposal for the study of this wonderful object have been further increased by the appearance of the valuable and laborious observations of the Great Nebula, and the measures of numerous stars scattered throughout it, which were left unpublished by the late Professor G. Bond. These researches have been carefully edited by Professor Safford, and they form volume V. of the *Annals of the Observatory of Harvard College*. The observations are accompanied by a very beautiful revised engraving of the Great Nebula from the drawings of Professor G. Bond.

D'Arrest's Catalogue of Nebulæ.

Our science has been enriched during the past year by the appearance at Copenhagen of an extensive Catalogue of the Nebulæ observed by Dr. D'Arrest, with the 11-inch refractor of the Observatory of that city, during the years from 1861 to 1867. The Catalogue contains 4800 separate observations of 1942 Nebulæ. Amongst the Nebulæ recorded there are about 390 which have been observed for the first time, or have not had their places determined previously with the accuracy necessary for their recognition. The value of this Catalogue is very greatly increased by numerous descriptions of the appearance of the objects observed, and micrometrical measures of such of them as admitted of this determination.

The Melbourne Reflector.

It will be source of much gratification to all who take an interest in our noble science that the present year will probably witness the erection at Melbourne, Australia, of a powerful telescope in some degree adequate to the exploration of the rich but hitherto very partially-explored regions of the southern heavens. The 4-foot reflector, now in Mr. Grubb's workshop, approaches completion, and according to Dr. Robinson's report, appears to be very successful in respect alike to its optical qualities and to the scarcely less important mechanical arrangements by means of which the observer may, without inconvenience or fatigue, direct and manipulate at his pleasure this magnificent instrument. The telescope is of the Cassegrain form of construction, and is mounted equatorially.

Dr. Robinson says, "The peculiar nature of the mounting brings the circles completely within reach of the observer's assistant; and the mechanical appliances for the motions in right ascension and polar distance are so perfect that we set the instrument on the faint objects which we were examining with great facility and rapidity. One man can reverse the telescope in a minute and a quarter; the quick motion in polar distance is far easier, and the slow one acts more like the tangent-screw of a circle than the mover of such a huge mass. The clock does its work with great precision, the objects remaining steady on the wire as long as I watched them; and there is an ingenious and new contrivance for suiting its speed to planets or the Moon."

The telescope is to be supplied with the necessary apparatus for photography and for spectroscopic investigation.

There still remains the important question as to the most convenient method of sheltering the instrument from rain, and especially from dust. A revolving roof, 46 feet in diameter, is at present suggested as the most expedient method.

Mr. Newall's Great Refractor.

By their successful completion of the bold undertaking to construct an achromatic object-glass, 25 inches in diameter, and 29 feet in focal length, Messrs. Cooke and Sons have done honour to our country, as well as performed a most important service for the science of Astronomy. They state that this magnificent telescope performs admirably, and that the character of the disks of stars seen in it are such as to show that the aberrations of this enormous glass have been properly corrected. The great weight of the two disks of glass forming the object-glass, which amounts to 146 lbs., has required a peculiar arrangement of levers to prevent flexure in the different positions of the telescope.

The equatorial mounting of the telescope is finished, and the expectation may be entertained, that, during the present year, it will reach Madeira, where it is to be placed under the care of Mr. Marth, who is already familiar with the use of large telescopes by the experience which he gained during his sojourn with Mr. Lassell at Malta.

A 7-inch transit-circle will complete this important astronomical establishment, which we shall owe to the munificence of our Fellow, Mr. Newall.

November Meteors.

The meteor shower of November 1867 was not well seen in Europe. The position of the radiant point was not favourable, and the sky was generally clouded. Enough, however, was seen to convince observers that a great display was in progress. The observations now coming in from the American Continent show that the shower of last November was but little inferior to that of 1866.

In the *Monthly Notices* for April will be found a discussion by Professor Adams, of the "Orbit of the November Meteors." Professor H. A. Newton, in his Memoirs, contained in Nos. 111 and 112 of the *American Journal of Science and Arts*, had discussed with great care the ancient records of November Showers, and shown that their principal features could be explained by supposing the meteoric matter to move in ellipses with periods of 180·0 days; 185·4 days; 354·6 days; 376·6 days, or 33·25 years. Professor Newton also determined the motion of the node of the orbit, to be about 29′ in 33·25 years. He suggested the possibility of determining which of the five periods, possible so far as the other facts were concerned, was the real period, by determining the disturbing action of the planets upon the orbit of the meteors. In this state the question was taken up by our Fellow, Professor Adams. He first determined the secular motion of the node, on the assumption that the period was 354·6 days, the period which Professor Newton considered the most probable. The motion of the node thus produced would have amounted only to 12′ in 33·25 years. The period of the meteoric matter could not, therefore, be 354·6 days. The periods 180·0, 185·4, and 376·6, proposed by Mr. Newton, would have given results less, or nearly equal to, that resulting from the period 354·6 days. Professor Adams, therefore, finally confined his attention to the period 33·25 years. With this period and a new determination of the other elements of the orbit, made from the observations of November, 1866, Professor Adams found the secular motion of the node in 33·25 years to be 28′; of which 20′ was due to the action of *Jupiter;* 7′ to the action of *Saturn;* and 1′ to the action of *Uranus.* The effects of the disturbing actions of the other planets were small. The close agreement of the theoretical value thus obtained by Professor Adams, with the observed value 29′, is undoubtedly sufficient to prove that the period of the November meteors is 33·25 years. This result of Professor Adams' investigation is probably the most important contribution Physical Astronomy made during the year.

The very close agreement pointed out by Signor Schiaparelli, between the orbits of the August Meteors and Comet II. 1862, and his bold speculation as to the identity of cometic and meteoric matter has been followed up by the reference of Comet I. 1866, to the November stream. The agreement of the elements of the orbit of Comet I. 1866, and the November meteors appears to have been first pointed out by Mr. C. F. W. Peters.

Parallax of 34 *Groombridge.*

The few stars, the parallax of which has been determined with more or less accuracy, were first pointed out as favourable objects for such an investigation by the extraordinary observed amount of their proper motion. 61 *Cygni* is remarkable for an annual progressive displacement amongst its apparent neighbours by a motion exceeding 5″ per annum. The valuable star-catalogues of the Bonn Observatory show that a similar proper motion of large amount distinguish some other small and inconspicuous stars. In the northern heavens after the five stars — 1830 *Groombridge*, 61 *Cygni*, *Lal.* 21185, *Lal.* 21258, and *μ Cassiopeiæ* — comes the star 34 *Groombridge*, 8.9 magnitude, which Krüger has shown to have an independent motion of 2″·84 yearly. The probable relative nearness to our system which this larger proper motion appeared to indicate induced Dr. Auwers to undertake the examination of the star for parallax. The method adopted by him was the chronographic registration of its Right Ascension in comparison with two neighbouring stars, one preceding it and one following it.

The observations on 79 nights extend during three years, and were made with the 6-foot Equatorial of the Observatory of Gotha. During the registration by the chronographic method the times of passage of 34 *Groombridge* and the two stars of reference across the 15 threads of the eye-piece, the telescope always remained unmoved in Right Ascension.

This carefully conducted investigation leads to a value of the parallax for the star, of the truth of which Dr. Auwers considers there cannot well be any doubt entertained.

If the stars of reference, which are 7 mag. and 8 mag. respectively, be supposed to have a mean parallax of 0″·015, with a mean error of ± 0″·009, the absolute parallax of 34 *Groombridge* will be

0″·307, mean error ± 0″·0376, probable error 0″·0254.

This value will place the star under investigation at a distance from us = 672,000 radii of the Earth's orbit, with a probable error of 56,000 radii. The light emitted by the star would require 10·6 years to reach the Earth.

There is another star of the 10·5 magnitude within 40″, which appears to be in physical connection with 34 *Groombridge*.

The probable relative nearness of this faint star, as shown by the investigation of Dr. Auwers, gives additional weight to the arguments which have been stated against the assumption that the apparent brightness of the stars may be received as an indication of their distance from our system.

Asteroids and Comets.

Four Asteroids have been discovered during the past year, viz.: (92) *Undina*, by Dr. C. H. F. Peters, at Hamilton College, U. S., on 1867, July 7; (93) and (94), by J. C. Watson, at Ann Arbor Observatory, U. S., on 1867, Aug. 24 and Sept. 6, respectively; and (95) *Arethusa*, by Dr. Luther, at Bilk, on Nov. 23.

Three Comets have been discovered during the past year.

Comet I. 1867, by Stéphan, at Marseilles, on January 22. The discovery of this Comet was mentioned in the last Report.

Comet II. 1867, by Tempel, at Marseilles, on April 3.

Comet III. 1867, by Bäker, a clockmaker, of Nauen, on the evening of Sept. 26, and four hours afterwards by Dr. Winnecke.

Our Fellows will, we are sure, receive with great satisfaction this proof of Dr. Winnecke's restoration to health, and return to the scene of his former labours.

Mean Distance of the Sun from the Earth.

In the *Monthly Notices* for May, 1867, will be found a short abstract of a paper by Mr. Stone, containing a numerical determination of the parallactic inequality in the Moon's motion, and a deduction of the corresponding value of the Solar Parallax. The coefficient of the parallactic inequality is found to be 125″·36 and the value of the solar parallax, 8″·85. A paper on this subject by Mr. Newcomb forms Appendix II. to the *Washington Observations* for 1865, published in 1867. This paper contains a careful re-discussion of the observations of *Mars* made near the Opposition of 1862, at the Observatories of Albany, Greenwich, Pulkova, Washington, Cape of Good Hope, Santiago, and Williamstown. The value of the solar parallax deduced by Mr. Newcomb is 8″·855. This value is smaller than 8″·964, deduced by Dr. Winnecke from a comparison of the Pulkova and Cape Observatories, and also smaller than 8″·943, the value found by Mr. Stone from a discussion of the Greenwich observations and corresponding observations at the Cape of Good Hope and Williamstown. There is unfortunately some objection to the use of the Santiago observations in an entire ignorance of the inclination of

University of MICHIGAN

the wire. It may be mentioned that the Santiago observations had previously been compared by Mr. Ferguson with twelve corresponding Washington and fifteen corresponding Albany observations of *Mars*. The results thus found for the solar parallax were respectively $8''\cdot834$ and $8''\cdot611$.

Binary Star Σ 3062.

The orbit of this close and interesting binary star has been calculated with much apparent care by M. Fuss. Since this star was discovered by Sir Wm. Herschel in 1782, it has performed more than three-fourths of a revolution. Its closest approximation took place about 1835, when it was $0''\cdot4\pm$. The results of M. Fuss's calculations give the following elements of its apparent orbit :—

	″
Semi-major axis	1·287
Semi-minor axis	0·999
Distance of principal star from centre of ellipse ..	0·416
Position-angle of the line joining both points ..	−36° 48′
Position-angle of line of apsides	+46 18

Rotation-Period of Mars.

By means of a careful comparison of the views of *Mars*, by different observers from Hooke in 1666 to Mr. Browning in 1867, Mr. Proctor concludes that

$$88642^{s}\cdot735 \quad \text{or} \quad 24^{h}\ 37^{m}\ 22^{s}\cdot735$$

may be accepted as very nearly the true value of the rotation-period of that planet.

Comet III. 1860.

The numerous exact observations which were made of this Comet in the summer of 1860, appeared to Dr. Auwers to furnish materials for a determination of its path more accurately than is usually possible in the case of these remarkable bodies.

The observations of the Comet at many Northern observatories, from June 18th to July 24th, were followed by observations made in the Southern Hemisphere, from July 8th to Oct. 18th, when it was seen for the last time at the Cape of Good Hope. During the four months of its visibility it had passed through an arc of 96°, as seen from the Sun. The whole of the curve, however, belonged to the same side of its path, as it had already passed its perihelion at the time of its discovery. Dr. Auwers was aided in his research by M. Sievers, who made a new determination of the places of 110 of the stars of comparison.

Dr. Auwers gives several determinations which differ but very slightly from each other. He appears to consider as most trustworthy those in which the more homogeneous materials only are employed. The following elements are those which result from his fourth determination :—

T = June 16·061003 Gr.
$\log q$ = 9·4666978
$\pi = 161^{\circ}\ 32'\ 27''\cdot 68$
☊ = 84 40 32·08
i = 79 19 25·47
Motion Direct.

Communications to the Society from February 1867 to February 1868.

1867.
Mar. 8. On the Planet *Mars*. Mr. Joynson.
On the compatibility of the retrograde motion of the November Meteors with the Nebular Theory. Mr. Hippisley.
On an Astronomical presentiment of Immanuel Kant relative to the constancy of the Earth's Sidereal Rotation on its Axis. Mr. Wackerbarth.
On the measurement of the Apparent Discs of Stars. Mr. Knott.
Notice explanatory of a series of MS. Charts containing the estimated Magnitudes of Stars visible to the Naked Eye in both Hemispheres. Sir J. Herschel.
Observations of a Meteoric Shower at Bishnagur, November 14, 1866. Mr. Masters.
Observations of *Iris* and *Vesta* at Dunsink. Dr. Brünnow.
Observations of the Eclipse of March 5, 1867. Mr. Brothers.
On the estimation of Star Colours. Mr. Kincaid.
On the Spectrum of *Mars*, with remarks on the Colour of the Planet. Mr. Huggins.
Determination of the coefficient of parallactic inequality and a deduction of the Sun's Horizontal Equatorial Parallax from the Greenwich Lunar Observations, 1848–60. Mr. Stone.
Observations of the Solar Eclipse, March 6, 1867. Capt. Noble.
Observations of the Meteoric Shower in Australia. Mr. Duone.
On the disturbance of the Solar Photosphere by Planets. M. Hoek.

A perfect form of Object-glass, deduced from a critical analysis of the Secondary Spectrum. Mr. Dawson.

On the Solar Eclipse of 1868, August. Major Tennant.

Observations of Solar Eclipse, March 5, 1867. Mr. Lassell.

Observations of Solar Eclipse, March 5, 1867. Mr. Prince.

Meteoric Shower of November 1866. Mr. Kincaid.

Meteoric Shower of November 1866, log of ship *Evangeline*. Capt. Wood.

Solar Eclipse, March 6, 1867. Lord Wrottesley.

April 12. Errors in Tables of Logarithms. Mr. Wackerbarth.

Observations of Solar Eclipse, March 5, 1867. Prof. C. P. Smyth.

On the Mass of the Moon, deduced from the Mean Range of Spring and Neap Tides at Dover. Mr. Finlayson.

Errata in his Logarithmic Tables of 1849. Major-Gen. Shortrede.

On the distribution of Nebulæ in Space. Mr. Cleveland Abbe.

Eclipse of the Sun, 1867, March 5, and Occultation of a Star by the Moon, 1867, January 16. The Astronomer Royal.

Errata in two Papers of his. The Astronomer Royal.

Motion of the Solar System in Space. Mr. Stone.

Note on the Calculation of the Sun's Parallax from the Lunar Theory by P. A. Hansen. Mr. Stone.

Determination of a slightly corrected Value of the Solar Parallax, from the data of Le Verrier's Solar Tables. Mr. Stone.

On the Heat attained by the Moon. Mr. Harrison.

Catalogue of New Stars. Mr. Chambers.

May 10. Additional Remarks on the Solar Eclipse of March 5, 1867. Mr. Brothers.

Observations of Comet II. 1867. Mr. Talmage.

Occultation of *Mercury* by the Moon, May 1, 1867. Capt. Noble.

June 14. On the connection between Comets and Meteors. Mr. Stoney.

Meteors observed 13–14 November, 1866. Mr. Burton.

On the earliest traces of good Practical Astronomy. Prof. C. P. Smyth.

On certain appearances of the Telescopic Images of Stars, described by Rev. W. R. Dawes. The Astronomer Royal.

Determination of the Longitude of the Sydney Observatory, from Observations of the Moon and Moon-culminating Stars made in 1859–60. Mr. Stone.

Approximate relative Dimensions of the Asteroids. Mr. Stone.
Observations in India of December Meteors, 1866. Mr. Masters.
Note on the Spectrum of Comet II. 1867. Mr. Huggins.
Occultation of o^2 *Libræ*, May 17, 1867. Mr. Talmage.
On the alleged change of focus requisite in observing Stars widely separated in altitude. Capt. Noble.
Measures of diameters of first bright ring of Star disk. Mr. Knott.
On the importance of Spectroscopical examination of vicinity of the Sun when totally eclipsed. Mr. Brayley.
Recents observations and remarks of Hofrath Schwabe regarding Sun Spots and other Solar Phenomena. Messrs. De La Rue, Stewart, and Loewy.
Note on the Lunar Crater *Linné*. Mr. Huggins.
Nov. 8. On the Transits of *Jupiter's* Satellites and the Lunar Eclipse. Mr. Weston.
Eclipses and Transits of *Jupiter's* Satellites. Mr. Weston.
Jupiter without his Satellites. Mr. Prince.
Note on the Appearance of *Jupiter*, August 21. Mr. Hough.
On the Solar Eclipse, August 1868. Mr. Stoney.
On *Jupiter* without Satellites exterior to his disk. Mr. Burr.
On the Annual Parallax of *Sirius*. Mr. C. Abbe.
On the Lunar Crater *Linné*. Capt. Noble.
Occultations of Stars by Moon, observed at Maresfield. Capt. Noble.
Note on the Lunar Eclipse, September 17, 1867. Capt. Noble.
Jupiter without a visible Satellite. Rev. W. R. Dawes.
Account of an Observing Chair. Rev. W. R. Dawes.
The November Meteors of 1867. Rev. W. Deey.
On the Newton-Pascal Controversy. Prof. Grant.
Determination of the Longitude of the Kingston Observatory. Mr. Williamson.
On some newly-discovered Stars near α *Lyræ*. Mr. Buckingham.
Dec. 13. On the November Meteors, 1867. Mr. E. J. Lowe.
Ditto ditto Mr. Kirkwood.
New Laws of Planetary and Satellitary Motions. Mr. Glennie.
Rotation of *Mars*. Mr. Proctor.
On the Colours of Stars. Mr. Browning.
On the Solar Eclipse of 1868, August 17–18. The Astronomer Royal.

Some remarks on the Value of the Solar Parallax. Mr. Stone.

On Bessel's Mean Refractions. Mr. Stone.

Attempts to facilitate the Prediction of Occultations and Eclipses. Mr. Penrose.

1868.

Jan. 10. *Jupiter* and his Satellites. Mr. Barneby.

Meteoric Shower, Nov. 14, 1867. Lieut. Chimmo.
Ditto ditto. Mr. G.W. H. Maclear.
Ditto ditto, observed at Nassau, Bahamas. Mr. Lawson.

On the Variable Star T *Serpentis*. Mr. Baxendell.

On a contrivance for Reducing the Angular Velocity of Meteors. Mr. Browning.

Inductive Proof of the Moon's Insolation. Mr. Harrison.

A determination of the Moon's Mass. Mr. Stone.

On the Minimum of U *Geminorum*. Mr. Knott.

A new law of the Distances of the Members of the Solar System. Mr. Glennie.

Discovery of a minute Companion to γ *Equulei*. Mr. Knott.

List of Public Institutions and of Persons who have contributed to the Society's Library, &c. since the last Anniversry.

Her Majesty's Government.
The Lords Commissioners of the Admiralty.
The Secretary of State for War.
The Secretary of State for India.
Royal Society of London.
Royal Asiatic Society.
Royal Asiatic Society, Bombay Branch.
Royal Geographical Society.
Royal Institution.
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Meteorological Committee, Bengal.
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Editors of Silliman's Journal.
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ADDRESS

Delivered by the President, the Rev. Charles Pritchard, on Presenting the Gold Medal of the Society to M. Leverrier.

The Society's Medal, at all times a subject of deep solicitude to the Council, has this year been awarded to M. Leverrier for his Solar and Planetary Tables. A brief inspection of the earlier pages of the *Nautical Almanac* will be quite sufficient to explain the desire which has long been felt by successive Councils publicly to testify to the distinguished Director of the Imperial Observatory of Paris, their deep sense of the services which he has rendered to astronomical science by the publication of Tables which in this country have superseded all others for the computation of the places of *Mercury, Venus, the Earth*, and *Mars*, in their respective orbits.

Probably few subjects connected with physical inquiries, on a first and distant view of them, present an aspect more unattractive than the contemplation or discussion of long and complicated Planetary Tables. To the mind unprepared, to the eye not specially educated, such Tables must necessarily appear little more than a repulsive mass of symbols, or a maze of numerical expressions strung together, no doubt, after some recondite, but to such a mind, assuredly, unintelligible scheme.

In addressing, however, the members of a learned Society such as ours, it may properly be assumed that the great majority have reaped the high reward of a diligent prosecution of the noblest of the sciences, and that to their minds, what seems to others a cheerless array of figures, becomes animated with intelligence, and illuminated with the light of thought. The well-instructed geologist, in the fragment of a rock, reads the history of the formation of an ancient continent; from a fossil bone he knows how, by his unerring curious art, to picture to himself the form, and the dimensions, and the habits of a creature whose span of existence, and all its concomitant relations, were allotted to it in ages long since passed away. In like manner the astronomer, in the long columns of the Tables before him, observes not a mere series of abstract numbers, but he traces therein the very pulsations of the planets as they are impelled hither and thither by the approach or recession of the celestial masses forming the system of bodies amidst which they move. He recognises therein the play and the interactions of the chief forces of the Universe. Nor is this all; for ever and anon these apparently lifeless symbols recall to his memory some high achievement of the genius of man; he reads upon the page the imperishable epitaphs of Newton or Bradley, or Lagrange, or Laplace, or Bessel; or he is invited to rejoice in the light of men worthy to be their successors and still spared to ourselves, such as Hansen, or Airy, or Adams, with Leverrier and Delaunay, and a host of others of no inferior fame.

You are aware that a series of modern tables intended to represent the motions of a planet consists, generically, of two parts; the former part representing the place which the planet would have occupied at any specified moment had its motion been calculated for a certain hypothetical but definite ellipse with the Sun in its focus; and the latter part furnishing the amount of deviation caused by the disturbing action of the other celestial bodies. The form, dimensions, and position of the afore-mentioned ellipse, are determined, with the exception of certain secular variations, for the most part by considerations depending on geometry and observation alone; and herein there come largely into play the perfection of the instrument and the skill of the observer. The deviations from this provisional or hypothetical orbit, arising from the perturbations of the other celestial masses, are calculated on the principles of the Newtonian theory as extended by the later investigations of Lagrange and Laplace. These disturbances or deviations from this elliptical motion depend on the masses, distances, and configurations of the planets, or of the elements of their orbits, and are never presumed to be exactly known: they are approximations only, representing more or less the truth of the case, though generally, as we shall see, to a wonderful, and it might be said, unhoped-for degree of precision. It is for very important additions made towards the exactness of these approximations, and for the convenient methods in which they are prepared and arranged for further improvements by future physical astronomers, that we are this day anxious to express our gratitude to the eminent Director of the Paris Observatory.

When M. Leverrier, in the year 1854, and seven years after the discovery of *Neptune*, was called to the direction of the Imperial Observatory, he found it in a condition of lamentable deficiency, to which we should not here have ventured to allude had not that able astronomer himself pathetically described his disappointment in the Annals of his own publication. Moreover, we shall find in the sequel that this very circumstance soon becomes associated with his fame. He states that, in the imperial city, long adorned by the genius of Laplace, and by the unrivalled analysis of Lagrange, until the year 1800 there was no transit instrument of any description existing within the walls of the Observatory.* It is still more incredible that, up to the year 1828, the instrument then provided was inferior to that with which Bradley had verified his immortal discoveries, and had laid the foundation of modern astronomy some seventy years before. Moreover, at the very time when the great Transit Circle at Greenwich was in full operation, there was not a telescope within the Paris Observatory admitting as much as the fourth part of the light which was then brought to the focus of the noble instrument at the disposal of the English Astronomer Royal, and constructed after the model proposed by himself. English politicians, and even English philosophers, have a peculiar, but well-known tendency to express dissatisfaction at their own national or official arrangements. If among the members of our Society there should chance to be any who are disposed to indulge in this luxury of self-dispraise, I am afraid that our distinguished Medallist has deprived them of, at least, one source of this gratification by his candid statement, that "The Paris Observatory, excepting at the epoch of Dominique Cassini, had always been half a century in arrear of Greenwich, so far as its instrumental resources were concerned."

All this unfortunate deficiency M. Leverrier, immediately upon his appointment, set himself diligently to repair, with the noble ambition of entering, as he says, "upon a pacific contest with other nations, for a place in the foremost rank of astronomical fame, and for the recovery and maintenance of the scientific renown of France."† The present reputation of the Imperial Observatory, and the high and undoubted estimation of its Annals by foreign astronomers, cannot fail to furnish, even to the laudable ambition of its Director, a satisfactory proof that these hopes have been fully realised.

At the time of the establishment of the Paris Observatory in its modern efficiency, M. Leverrier found that, either by mutual arrangement or by prescription, the other great National Observatories had appropriated each to itself a special line of astronomical observation. Greenwich, in obedience to the wise directions of a

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* *Annales de l' Observatoire Impériale*, vol. i.

† Ib.

Royal Warrant, had become unrivalled for its accurate and persistent observations of the Moon, and of such other phenomena as might contribute to the furtherance and security of the Art of Navigation. Pulkowa, under the direction of the elder Struve, had long gained a well-merited reputation for the advance which had there been made in Sidereal Astronomy. M. Leverrier entered upon his career of a friendly rivalry with these noble institutions by at once assuming for himself the unappropriated but laborious task of recomputing the tabular places of the Planets, on the basis of the analysis of Laplace, with the utmost attainable rigour of exactness, and of then comparing these theoretical places with actual observation. The discordances, however small they might be, between the computed and the observed places, those *residual phenomena*, always so pregnant with the germs of knowledge, would, he hoped, at length lead to the discovery of some hitherto unnoticed action, either of some small interplanetary masses of matter such as meteoric matter, or of cometic matter, or of the matter from whence emanates the zodiacal light; or otherwise might disclose the existence of some intra-Mercurial planet, or of some other forces as yet unsuspected in nature. Such was the aim of this eminent astronomer: an aim worthy of the noblest scientific ambition, but one which would demand the aid of the most subtle resources both of observational and of physical astronomy.

The systematic pursuit of this object required many preparatory and most laborious arrangements. Among others it was imperatively necessary to obtain the best available observations of the Sun and the Planets, commencing from a period as remote as possible from the present epoch. For such a purpose the earliest available materials were the observations of Bradley and of his successors at Greenwich; a few others were to be found in the records of Paris and of Königsberg. With regard to the observations made by Bradley more than a century before M. Leverrier commenced his investigations, it was remarked that his instrumental means and his mode of adjusting his instruments, although the best of his day, were not comparable to those put into modern requisition. The aperture of his transit was exceedingly small, the object-glass was not achromatic, the eye-piece admitted of no sliding arrangement, and the records of the state of the adjustment of the instrument are frequently perplexing and obscure. The object which M. Leverrier had in view was to ascertain the true right ascension and the true time of transit of the Sun and the Planets across the meridian at Greenwich during the century which ended on the 1st of January, 1850. Bessel had already done much towards the reduction of Bradley's observations of 36 'Fundamental Stars,' but M. Leverrier did not consider the results as altogether possessing the rigorous precision required for his present purpose, and he accordingly set himself manfully to the task of completing the reduction of the Right Ascensions of these same 36 Fundamental Stars which had been diligently observed during the entire century. The completion of such a work, under the direction of a single person, *on a single plan*, and conducted with so much intelligence and care, has conferred a great boon upon astronomers, and forms one of the reasons for which we are this day anxious to express our gratitude.

Again, for the effectual prosecution of M. Leverrier's great design, it was necessary to complete and extend, to a far closer amount of approximation, those formulæ for the Planetary Theory which had been invented or perfected by Laplace. That great geometer, in his immortal work the *Mécanique Céleste*, had indicated those terms only in the expressions for the co-ordinates of a planet which he considered would rise to a sensible amount in a numerical computation. It was on this basis that Carlini calculated his Solar Tables, and that Lindenau executed his for *Mercury*, *Venus*, and *Mars*. These tables of Carlini and Lindenau were long used for the computation of the Solar and Planetary co-ordinates in the *Nautical Almanac* with fairly satisfactory results; but for M. Leverrier's purpose of obtaining the small outstanding residuary differences between observations and the best results of the present theory, they were not deemed sufficiently exact.

For the purposes of improving these Solar and Planetary Tables, M. Leverrier, in the year after his appointment to the Directorship of the Paris Observatory, published in the first volume of the *Annales de l'Observatoire Impériale*, a complete reinvestigation of the whole theory of planetary motion on the basis of the method pursued by Laplace. In particular he expanded the *disturbing function* to a greater extent than it had ever been completely expanded before, leaving it with its numerical coefficients computed to the seventh order of small quantities. Thus one most important result of M. Leverrier's labours consists in this, that he has left the general theory in such a state of advanced development, that its practical application henceforth to the case of any particular planet has become greatly simplified and attended with far less labour than had been the case hitherto.

These laborious preliminary calculations having been thus disposed of, and, what is still better, having been published for the advantage of future astronomers, our distinguished Medallist then proceeded to apply them to the construction of Tables for the positions of the Sun, *Mercury*, *Venus*, and *Mars*, carrying the approximations to a greater degree of minuteness than had ever been effected before. These Tables, as we have already stated, have with excellent results superseded those heretofore in use for the computation of the *Nautical Almanac*.

The question will have occurred to those who have listened to the details of the present address — and I greatly wish that it had been possible to present them to you in a more interesting and agreeable form—the question, I say, naturally arises, What is the degree of accordance between the observed places of the Sun and the Planets, and those which have been thus calculated with all this extraordinary care?

In reply to this question I have been favoured by the Astronomer Royal with the following extracts from observations made and recorded at Greenwich. It is necessary to understand that, in order to eliminate mere accidental errors of observation, it is usual to group together several observations extending over intervals of time during which the error of the Tables may be supposed to change sensibly by quantities depending on the first power of the time.

It is to such mean errors of groups that the following numbers refer:—

Solar Tables.

Mean errors in longitude.

From Carlini	1861,	+ 2″·36
	1862,	+ 2·67
	1863,	+ 2·98
From Leverrier	1864,	+ 0·01
	1865,	+ 0·29
	1866,	− 0·18

The greatest discordances between "monthly mean errors in longitude," were

From Carlini	1861,	1″·97
	1862,	2·67
	1863,	5·21
From Leverrier	1864,	1·73
	1865,	1·88
	1866,	1·69

The improvement here is marked, but Carlini's Tables represented the observations well, and the discordances 1″·73, 1″·88, 1″·69, are larger than could be wished. It is possible, however, that these discordances may not be principally sole errors of theory, but errors introduced into the arbitrary constants from small systematic errors in observation.

The following are the greatest discordances of the mean errors in geocentric longitude for *Mercury*, *Venus*, and *Mars*:—

Mercury.

From Lindenau	1861	9″·79
	1862	10·20
	1863	17·94
From Leverrier	1864	5·29
	1865	3·30
	1866	2·04

Venus.

		″
From Lindenau	1862	15·97
	1863	34·67
	1864	19·05
From Leverrier	1865	5·44
	1866	6·44

Mars.

		″
From Lindenau	1862	8·81
	1864	13·98
From Leverrier	1866	0·31

The observations in 1866 are, however, very few.

From the above comparisons, it appears that M. Leverrier has made a notable and important advance in the accuracy of his Tables beyond those of his predecessors. We may, perhaps, form a general notion of the amount of accuracy obtained by observing that the average of the discordances between the observed and calculated places of these three planets during any month, rarely or never exceeds a small fraction of the apparent diameter of the disk of the planet itself. Whether these minute discordances, trifling as they are, indicate some slight imperfection in the mode of observing, whether they result from some deficiency in the application of the ordinary theory, or whether they arise from the existence of some exceedingly small masses of matter not taken into the account of the various attractions, it seems as yet impossible to decide. Happily something yet remains to test the efforts and exercise the sagacity of future astronomers.

At the commencement of this Address, I observed that, notwithstanding the forbidding aspect of the long array of figures in the Planetary Tables, to the initiated they contain a history, and are fraught with the memories of life: they are, in fact, the embodiment of some of the most remarkable and most difficult achievements of the human intellect. In order to illustrate what I mean, I shall first of all select one or two of those terms from the series representing the longitude of a Planet, and which arise from the discoveries of the eighteenth century; and then conclude the illustration before us with two other terms intimately associated with the labours of the eminent man whose services to Astronomical Science we hope to recognise to-day.

It follows from comparatively simple dynamical considerations—we say comparatively, because in reality the very simplest processes of Physical Astronomy require a considerable mental effort to be thoroughly grasped—it follows, we say, from the theory of gravitation, that the Moon's disturbing force on the Earth is such as to cause, not the Earth itself, but rather the centre of gravity of the Earth and Moon, to describe an ellipse round the

Sun. This disturbing action can be shown, again happily from considerations of less than usual complexity, to cause a displacement of the Sun in longitude, oscillating backwards and forwards along the ecliptic, and going through all its phases, in the course of a month. From the principles of gravitation alone, this displacement, when at its greatest, can be expressed in terms of the ratio of the masses of the Earth and Moon, and the ratio of the distances of the Earth from the Sun and from the Moon. Now means exist for obtaining the ratio of these masses, as well as the distance of the Earth from the Moon. This greatest displacement, therefore, of the Sun in the ecliptic, arising from the disturbing action of the Moon, can thus, from theory, be virtually expressed in terms of the distance of the Earth from the Sun. But M. Leverrier, by a very careful discussion of the Greenwich Observations, obtained the amount of this displacement of the Sun in longitude, to an unusual degree of accuracy, and he showed it to amount to six seconds and a half in space. By equating, therefore, the *theoretical* value of this *Lunar Equation*, as it is called, thus expressed in terms of the Sun's parallax, with the $6''\cdot5$ obtained from *observation*, the Sun's parallax itself was obtained by M. Leverrier, probably to a greater degree of accuracy than it had ever been obtained before. The result was to increase the solar parallax from the received value of $8''\cdot5776$ to $8''\cdot95$, or what amounts to the same thing, the distance of the Earth from the Sun was thus reduced from about 95 millions to about 91 millions of miles.

It is not pretended that there was anything essentially new in this application of the theoretical value of the *Lunar Equation* in the Solar Tables, to the determination of the Sun's parallax; M. Leverrier's merit therein consists mainly in his able and accurate discussion of the Greenwich Observations of the Sun. By a curious coincidence, about the same time that M. Leverrier proposed this important correction of one of the prime elements in the Solar System, M. Foucault, whose lamented decease we are now deploring, obtained a similar result from careful experiments on the velocity of light; and still further confirmation of the accuracy of the whole investigation has accrued, from a careful discussion of recent observations on *Mars* at his opposition. We shall, perhaps, have completed the history of the case if we incidentally mention that the necessity of greatly increasing the value of the solar parallax had already been indicated by Hansen's accurate determination of that term in the Lunar Theory which expresses the *reaction* on the Moon herself, of that same force which we have seen disturbs the longitude of the Earth. We here refer to these things, not on account of any particular novelty in the processes themselves, but rather as an illustration of the historical circumstances, or it may be even the cosmical relations, which are sometimes wrapped up in the apparently uninteresting coefficients of detached terms in the Planetary Tables. Even in their intellectual aspect alone, such considerations are invaluable.

With reference to those terms in the Planetary Tables, which, as I said at the commencement of this Address, recall to us the grand memories of the Astronomers of the eighteenth century, our comments must necessarily be very brief. Herein I can do little more than hint at those analytical expressions which remind us of that acute sagacity, and that unwearied patience which is born from conviction, whereby Bradley disentangled the combined action of the motions of the Earth and of Light, from a labyrinth of discordances in his observations of the stars. And then other terms closely follow, completing the story of Bradley's fame. Those mysterious symbols indicate to the instructed mind how, in the small residual discordances which still remained, the great English Astronomer detected the action of the Sun and the Moon, displacing hither and thither the axis of the Earth's diurnal rotation, after a complicated but intelligible law.

There is also another term at the commencement of the series for the calculation of the longitude of the Earth, which is intimately associated with the records of the genius of the greatest of the French Astronomers. It is a term relating to the varying eccentricity of the terrestrial orbit. Laplace referred it to the action of the planets on the motion of the Earth round the Sun. He showed how, by slow degrees, and within certain definite limits, these celestial masses must cause an alternate approach or recess of the Earth towards or from the Sun. With a sagacity, perhaps, never surpassed in the history of science, Laplace showed how this alteration in the eccentricity of the terrestrial orbit, must be accompanied by a corresponding small alteration in the average length of *a month*. And here, again, the small but *definite* amount of this alteration in the length of the month, in the hands of this great philosopher, was made subservient to the demonstration of the constancy of the length of the terrestrial *day* within the limits of historical time. All this curious history is, in reality, wrapped up in one little symbol in the series which represents the motions of a planet. But there is something more curious still behind. In process of time our own Adams detected an error both in the physical considerations, and in the analysis, of Laplace. The great French astronomer had, in fact, miscalculated the alteration of the average length of the month in the course of centuries; and then by a curious interaction it followed next that the length of the day itself must have been slowly decreasing, at all events since the date of very certain remote eclipses of the Sun. This scientific romance was completed by the recent demonstration by Delaunay, that the rotation of the Earth is truly retarded to a trifling but definite extent by the friction of the tides. When the history of this recent Episode in Astronomy comes to be fully written, it will probably be acknowledged as one of the most remarkable and instructive narratives in the annals of science.*

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* See Addendum to this Address.

There is no part of M. Leverrier's investigation of the Solar Tables in which he has displayed greater acumen and completeness than in his discussion of the secular effects of planetary interactions on the eccentricities of their several orbits. This is a branch of Physical Astronomy peculiarly intricate and laborious, and much interest attaches to it, because, independently of its historical relations already explained, it is here especially that Lagrange, in his magnificient handling of the analysis, unconsciously fell back upon the equivalent of that self-same mode of representing planetary motions by cycle on epicycle, and orb rolling on orb, which was so ingeniously adopted by the ancient astronomers.

But it is not merely on account of the interest thus attaching to this portion of Astronomy, in a geometrical or historical point of view, that I select it now for the consideration of our Society, but much more because the investigation has been supposed by some eminent philosophers to be fraught with information relative to the physical condition of our globe in ages long anterior to historic date.

It has latterly been one of the most pleasing tasks of those who have had the responsible honour of occupying this chair, to expatiate on the unexpected closeness of the connection recently discovered between great cosmical phenomena and ordinary terrestrial physics. This wonderful continuity of plan has been exhibited, we know, in the physical constitution of the Sun and of the Stars, and in the identity of the orbits of revolution of meteoric and cometic matter; and here again, in this perhaps the most intricate of planetary interactions, we stumble, as it were, upon an unexpected relation between the forces of the far distant celestial masses, and one of the most remarkable of geological phenomena: a relation, moreover, which possibly affords us some clue to the distance of that ancient epoch when our globe first became fitted for the abode of animated existence.

We have seen that the eccentricity of the approximate ellipse described by the Earth round the Sun is in a state of extremely slow but constant flux. This effect is brought about not by any alternations in the configurations of the planets, but by a corresponding flux and reflux in the *forms and positions of the orbits* themselves, even *Neptune* contributing a share which is within the limits of calculation. At the present time the Earth is about three millions of miles nearer to the Sun in our northerly winter that in our summer; our coldest month is about 60° Fh. colder than our hottest, and our winter lasts for about eight days longer than our summer. M. Leverrier has calculated* that 200,000 years ago, the Earth approached the Sun by upwards of ten millions of miles nearer in winter than in summer; the winters were then nearly a month longer than the summers, and in the latitude of London there was a difference of about 112° Fh. between the hottest and the coldest periods of the year. Eight hundred and fifty thousand years ago these differences, both of distances and of temperatures, were still further exaggerated.

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* *Annales de l'Observatoire*, vol. ii. addition iii. page [29].

The question then arises, Was any one of these great alterations of terrestrial temperature the cause, or among the concurrent causes, producing that *Glacial period* which has left behind it so many unmistakable and interesting phenomena? This question, surrounded by many complications, arising chiefly from possible alterations in the levels and configurations of terrestrial continents, especially in the neighbourhood of the North Pole, has been discussed with great moderation and in a truly philosophical spirit by Sir Charles Lyell, in the recent edition of his *Principles of Geology*.* The entire argument, as set forth by this eminent geologist, is well worth consultation; I shall here merely state that, upon the whole, Sir Charles Lyell considers there arises a probability that the great Glacial Period began to set in nearly *a million* of years ago. The argument, however, proceeds a step further in advance; for, inasmuch as naturalists have observed that "ninety-five in a hundred of the shells of the Glacial Epoch were specifically identical with those now inhabiting the northern hemisphere, we may consider a million of years to represent the twentieth part of a complete revolution in species." Arguing in this way, the conclusion at last is drawn that, speaking after the roughest of approximations, "*two hundred and forty millions of years may be the entire series of years which has elapsed since the beginning of the Cambrian period.*"

It is but right to remark that, notwithstanding the cautious and philosophical tenor of the reasoning employed, the approximation is admitted to be rough in the extreme; the marvel is that, by the force of the genius so bounteously given to man, he should be enabled to penetrate, or hope to penetrate, into depths of such mysterious profundity. It will be gratifying to the Astronomical Society to learn that our Secretary Mr. Stone† was the first person to extend the calculation of M. Leverrier's formulæ to the remote periods in question. Subsequently, Mr. Croll carried the computations even to a greater extent.

Such, then, are some of the historical circumstances and the physical consequences associated with that apparently forbidding and interminable array of figures‡ and symbols which M. Leverrier has arranged with such indomitable patience and consummate skill, for the computations of the eccentricities of the planetary orbits at periods whose remoteness exceeds the limits of our conceptions.

There may be, and probably there are, some minds to whom these investigations convey an ill-defined but painful sense that man is overstepping his proper place in nature, when he attempts to peer into such extreme remoteness of the past or the future. Assuredly it is not very uncommon to hear similar speculations associated with a rebuke on the score of the *pride of intellect*, which they are presumed to imply. In reference to such apprehensions, it may be sufficient to remark that we know not as yet, and we never can know except by making the trial, what may be the extent of the intellectual powers with which it has pleased the Sovereign Father of all to endow His children.* Assuredly man is bound, in all gratitude and loyalty to the Giver, to exercise to the utmost all the precious gifts which are entrusted to his care. It is a high quality, moreover, of these gifts, that they grow brighter by the using. As to pride of intellect, the gifted men who have been permitted to disclose to their fellow-creatures such onward stretching and magnificent views of the works of the Creator, know too well,—I had almost said, know too sadly, how vast is the labour, how perfect is the patience, and how limited is the power, with which such accessions to their knowledge are acquired; and Pride is not ordinarily the offspring of Labour and Patience and conscious Limitation of Ability.

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* Edition *Ten*, vol. i. page 293.

† *Phil. Magazine*, June 1865.

‡ As a matter of curiosity, or for the convenience of such of the Society as may not have easy access to the *Annales de l'Observatoire*, I insert M. Leverrier's

Such, then, is a brief account of some of the labours of M. Leverrier during the twenty-one years which have elapsed since, in association with our own countryman, in the happiest and most memorable of the discoveries of modern times, he gave to the

---

formulæ for computing the eccentricity of the terrestrial orbit, as influenced by the disturbances of all the planets excepting *Neptune*.

Eccentricity of the Earth's orbit (t) years after Jan. 1, 1850 $= \sqrt{h^2 + l^2}$

where

$$h = 0''{\cdot}000526 \sin(g\,t + b) + 0''{\cdot}016611 \sin(g_1 t + b_1) + 0''{\cdot}002366 \sin(g_2 t + b_2)$$
$$+ 0''{\cdot}010622 \sin(g_3 t + b_3) - 0''{\cdot}018925 \sin(g_4 t + b_4)$$
$$+ 0''{\cdot}011782 \sin(g_5 t + b_5) - 0''{\cdot}016913 \sin(g_6 t + b_6)$$

and

$l = 0''{\cdot}000526 \cos(g\,t + b)$ + the terms above, substituting *cosine* everywhere in the place of *sine*.

$g = 2''{\cdot}25842$ $\quad g_1 = 3''{\cdot}71364$ $\quad g_4 = 7''{\cdot}5747$

$b = 126^{\circ}{\cdot}43'\ 15''$ $\quad g_2 = 22{\cdot}4273$ $\quad g_5 = 17{\cdot}1527$

$g_3 = 5{\cdot}2989$ $\quad g_6 = 17{\cdot}8633$

$b_1 = 27^{\circ}\ 21'\ 26''$ $\quad b_4 = 35^{\circ}\ 38'\ 43''$

$b_2 = 126\ 44\ 4$ $\quad b_5 = -25\ 11\ 33$

$b_3 = 85\ 47\ 45$ $\quad b_6 = -45\ 28\ 59$

It may be worth observing (to the uninitiated) that each of the seven sines or cosines refers to the interaction of the seven bodies in the solar system: the action of *Neptune* is omitted. See *Annales de l'Observatoire*, vol. ii. p. 170.

* I trust I may be here permitted, without infringing the laws of good taste, to state that I have endeavoured to discuss this and kindred questions, in the Hulsean Lectures recently delivered before the University of Cambridge, and previously in two sermons preached before the British Association in 1866 and 1867. These are now published by Deightons, Bell and Co.

world ample proof of the rare genius with which he has been endowed. These successful labours,—and they necessarily form but a small part of the occupations of his busy life,—are, I am sure, more than sufficient to secure your cordial and unanimous ratification of the act of your Council, whereby they desire to testify to M. Leverrier their deep appreciation of the important services which he has rendered to Astronomical Science.

Admiral Manners,—In the name of the Royal Astronomical Society, I beg you to convey this Medal to M. Leverrier, the eminent Director of the Imperial Observatory of France.

We hope that the sight of it from time to time may properly serve to remind him, how intelligent fellow-labourers in another country appreciate the great work which he has already done in the service of the most sublime of the sciences; we trust also that it may assure him of the sympathy which we feel in the important and difficult investigations in which he is engaged.

Let the cheerfulness and the pride with which we make the award, afford to M. Leverrier an additional ground for the conviction, that we Englishmen entertain a profound respect for the great Philosophers of France.

And now, Gentlemen, my agreeable work in the service of our noble Society has, by inexorable law, at length, and to my regret, come to its close. In this chair I have passed, assuredly, many of the most memorable, and not a few among the most pleasant hours of my life. Owing to your habitual kindness and forbearance, I am sure that other Presidents must have felt, on an occasion like the present, just as I feel.

One chief element in the gratification which I thus venture to express has arisen from the continued and increasing prosperity of the Society itself.

During the eight years of my close and official relations to the Astronomical Society, whether as one of your Secretaries or as your President, I have enjoyed the pleasure of seeing the numbers who attend your evening meetings more than doubled; the Society itself has increased by nearly a hundred members, and its funded property has been augmented by more than two thousand pounds. Such has been the necessary consequence of consistent perseverance in a plan originally well devised; happily such is the natural fruit of a Society dwelling together in unity. Accept my hearty thanks, and, by the continued maintenance of good fellowship in its highest sense, realize my prayer, *Esto perpetua.*

ADDENDUM.

On revising the paragraphs in page 118 relative to the action of the tides in retarding the diurnal rotation of the Earth, I am reminded, both by the Astronomer Royal and by Mr. Stone, that a somewhat modified and more guarded statement is required by the facts of the case.

Soon after M. Delaunay published his investigation of the effects of tidal friction on the length of the day,* Mr. Airy entered upon an examination of the question, and at first came to a conclusion not confirmatory of M. Delaunay's result:† on subsequently pushing the approximation a step further, in an Addendum to the same communication in the *Monthly Notices*, the Astronomer Royal says: "I have at length discovered two terms which appear to exercise a real effect on the rotation of the Earth;" and then this important and most interesting memoir concludes as follows: "I am very happy to give my entire assent to the general views of M. Delaunay on the existence of one real cause for the retardation of the Earth's rotation."

Since the publication of these Memoirs by M. Delaunay and Mr. Airy, the whole question has been discussed under a variety of points of view, and various objections have been made to the results supposed to be deduced from the mathematical expressions.

Mr. Stone, for instance, from the very first declined to accept, without reserve, the conclusions deduced by M. Delaunay, mainly on the ground that the hypothesis on which the investigation is founded, presumes that the Moon's action is on a *solid* instead of a *fluid* spheroidal shell surrounding and moving round the Earth.‡

Mr. Airy also observes that his own investigation applies to the motion of water in an *uninterrupted* canal surrounding the Earth, and that the obstacle of a continent, such as that of America, might very seriously modify the final result.

It is, however, due to M. Delaunay to state that he saw himself the extreme difficulty, if not the impossibility, of arriving at any precise quantitative result by means of mathematical calculation alone; he says:§ "The exact calculation of the retardation due to the combined action of the Moon and Sun, would require a knowledge of all the circumstances of the tides *as well along the shores as in mid-ocean.* Such a direct calculation is impossible; the actual retardation can only be found indirectly by means of the lunar acceleration, as determined by observation;

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* *Comptes Rendus*, Dec. 1865, and *Monthly Notices*, Jan. 1866.

† *Monthly Notices*, April, 1866, p. 227.

‡ Ib. Jan. 1866.

§ Ib. Jan. 1866, p. 89.

and this gives a new interest to the comparisons of the lunar tables with the ancient eclipses, in the view of thereby arriving at the true value of the lunar acceleration."

At present, then, the case stands thus,—the Lunar Tables, if calculated on the principles of gravitation alone, as expounded by Messrs. Adams and Delaunay, and as confirmed by other mathematicians, will not exactly represent the Moon's true place at intervals separated by 2000 years, provided the length of the day is assumed to be uniform and unaltered during the whole of the intervening period. There are grounds, however, for at least suspecting that, owing to the effects of tidal action, the diurnal rotation is, and has been, in a state of extremely minute retardation, but the mathematical difficulties of the case, owing greatly to the interposition of terrestrial continents, are so great that no definite quantitative results have hitherto been attainable. The solution of the difficulty is one of those questions which are reserved for the Astronomy of the future.

The Meeting then proceeded to the election of the Officers and Council for the ensuing year, when the following Fellows were elected:—

President:

Admiral R. H. Manners.

Vice-Presidents:

J. C. Adams, M.A. F.R.S., Lowndean Professor of Astronomy, Cambridge.
G. B. Airy, M.A. F.R.S., Astronomer Royal.
A. Cayley, M.A. F.R.S., Sadlerian Professor of Geometry, Cambridge.
Rev. Charles Pritchard, M.A. F.R.S.

Treasurer:

Samuel Charles Whitbread, Esq., F.R.S.

Secretaries:

William Huggins, Esq. F.R.S.
Edward J. Stone, Esq. M.A.

Foreign Secretary:

Lieut.-Col. Alexander Strange, F.R.S.

Council:

Rev. Professor Challis, M.A. F.R.S.
Rev. W. R. Dawes, F.R.S.
Warren De La Rue, Esq. F.R.S.
Edwin Dunkin, Esq.
George Knott, Esq.
William Lassell, Esq. F.R.S.
J. Norman Lockyer, Esq.
Rev. Robert Main, M.A. F.R.S., Radcliffe Observer.
Captain William Noble.
Richard A. Proctor, Esq. B.A.
William Simms, Esq.
Isaac Todhunter, Esq. M.A. F.R.S.

The Lunar Crater Linné.

Captain Noble remarks, in regard to the Editor's note, p. 49, that, while Mr. Huggins' sketch shows a minute black crater surrounded by an ill-defined nebulous mass, his own exhibits a relatively shallow crater casting a perceptible shadow from the W. and S.W. wall, but without exhibiting any trace whatever of the smaller one.

Resolution of Council.

At the Council held Saturday, February 8, it was resolved that a paper cannot in general be read at an Evening Meeting unless the same shall have been deposited at the Society's rooms by noon of the day of Meeting.

For Sale.

A transit instrument and clock. The transit instrument, by Jones, is of 3¾-in. aperture and 5-feet focal length and firmly mounted on stone piers. The clock, by Hardy, is a very good one, there being no difference between its summer and winter rates. Apply to Mr. Hough, Wrottesley, Wolverhampton.

Superior Achromatic Refractor, 4¼ inches aperture, by Mr. Peter Dollond, 6 feet focal length, with finder and four eye-pieces, mounted on new improved Varley's Stand. Price £30. Apply to Edward Crossley, Halifax.

CONTENTS.

	Page
Fellows Elected	57
Report of the Council	ib.
List of Papers read from February 1867 to February 1868	100
List of Donors to the Library	103
List of Institutions and Individuals who receive the Society's Publications	106
President's Address on delivery of the Gold Medal to M. Leverrier ..	110
Addendum	123
Election of Officers and Council	125
The Lunar Crater *Linné*	126
Resolution of Council	ib.
Instruments for Sale	ib.

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MONTHLY NOTICES
OF THE
ROYAL ASTRONOMICAL SOCIETY.

VOL. XXVIII. *March* 13, 1868. No. 5.

Admiral **MANNERS**, President, in the Chair.

The Rev. Joseph Spear, Chaplain, Bengal Establishment, Meerut,

was balloted for and duly elected a Fellow of the Society.

On the Comets 1857, *III. and V., and* 1867, *III.* By M. Hoek, Director of the Observatory of Utrecht. (Translation.)

In an addition to my Memoirs on Cometary Systems, see *Monthly Notices*, vol. xxvi. page 204, I have indicated the point of the sphere

IV. $\lambda = 75^\circ{\cdot}5 \quad \beta = -51^\circ{\cdot}7$ .. Mean equinox of 1864·0,

as being probably a radiant point of cometary orbits.

I have therefore regarded as a remarkable circumstance, giving much interest to this point, its small distance from the point

$\lambda = 73^\circ{\cdot}2 \quad \beta = -51^\circ{\cdot}6$ .. Mean equinox of 1864·0,

which was the point of intersection of the orbits obtained for the Comets 1857, III. and V.

I did not hesitate to attribute to these two bodies a common origin, considering the extreme resemblance of all the elements of their orbits, and the short interval between their appearance.

The Comet 1867, III. has just given an unexpected confirmation to this view. The circle which is the intersection of its orbit with the sphere passes through almost the same point of the sky.

The planes of the three orbits intersect therefore in the same line, which is necessarily parallel to the direction of the initial motion of the Comets.

Admitting for the orbits the following elements,

	Comet 1857, III.	1857, V.	1867, III.	
T	1857·54	1857·74	1867·85	
π	157° 52	139° 54	112° 58′	Mean equ. of 1864·0.
☊	23 47	15 4	64 42	
i	121 3	123 57	96 14	
q	0·3675	0·5628	0·3333	
Calculator.	Villarceau.	Linsser.	Oppolzer.	

I find for the points of intersection

of the Orbits	1857, III. and 1857, V.	λ = 73° 12′	β = − 51° 36′
,,	1857, III. and 1867, III.	72 32	− 51 19
,,	1857, V. and 1867, III.	72 33	− 51 23

of which the first is only half-a-degree distant from the two others.

These three Comets, then, have a common origin.

As to the aphelia they are situated at a considerable distance from the radiant point of the orbits. I find

For the Comet	Aphelion.		Distance of the Aphelion from the Radiant Point.
1857, III.	λ = 51°·8	β = − 38°·0	20°·0
1857, V.	53·8	− 42·9	15·4
1867, III.	68·5	− 31·5	20·1

but, what is remarkable, all the aphelia are on the same side as regards the radiant point. In following the orbits in the direction of the retrograde motion, we meet the radiant point before we arrive at the aphelia. The last ten years have thus furnished us with two cometary systems, each composed of three members; first, that of the years 1860 and 1863, then that of the years 1857 and 1867.

It appears that it would be to mistake the principles of the theory of probabilities, if we attributed all these coincidences to mere chance.

Since I have been occupied with these researches, the calculations of M. Schiaparelli on the current of meteors coming from the stellar spaces have strongly corroborated my conclusions. This Astronomer has succeeded in showing the intimate connexion which there is between comets and falling stars; an important discovery, and known now to all the world. Naturally it has suggested the idea of seeking, if I could not find, a connexion between cometary systems and falling stars. In a subsequent Memoir I shall occupy myself with the theory which ought to serve as a guide in this investigation.

On the Phenomena which a very extended Swarm of Meteors coming from Space presents after its entry into the Solar System. By M. Hoek, Director of the Observatory of Utrecht. (Translation.)

I propose to examine in this Memoir the phenomena which will be presented by a swarm of corpuscules coming to us from the stellar spaces, and which is sufficiently extended to embrace the whole terrestrial orbit, that is, to give us a continuous rain of meteors during an entire year.

I shall determine the orbit of each molecule, the density of the swarm in the neighbourhood of the terrestrial orbit, the variations in the position of the radiant point, and lastly, the perturbations produced by the attraction of the Earth. But as we are only concerned with a first approximation, I shall admit that these corpuscules do not exercise any mutual influence, and that consequently their initial motions are parallel, and further that the initial velocity common to all the particles is that given by parabolic orbits round the Sun. Lastly, I shall neglect the ellipticity of the orbit of the Earth, and I shall consider this planet as a body composed of homogeneous and concentric spherical layers.

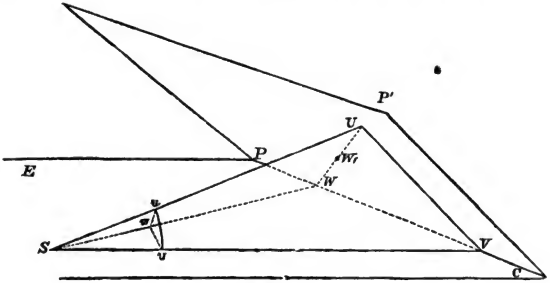

Fig. 1.

§ 1. Let E C (fig. 1) be the plane of the ecliptic, S the Sun, S U a line parallel to the initial motion of the swarm, motion with which each molecule enters into the sphere of activity of the Sun.

Let us write $SU = A$, and determine the direction of this line by the longitude L and the latitude B of the point U; and, to fix the ideas, let this latitude be taken to be northern.

Let PP' be a plane normal to the line SU, cutting the ecliptic in PC. Lastly, let SUV be a third plane normal to the two others and containing the line SU. We have $USV = B$.

Suppose now that a corpuscule passes through any point whatever W situate in the plane PP' and determined by the co-ordinates VUW_1, $= \zeta$, UW_1, $= s$. The orbit of the meteor round the Sun will be included in the plane USW, the position of which is easily determined. For this purpose let us represent to ourselves about the Sun as centre a sphere radius unity, and we shall have a spherical triangle uvw, the elements of which will be

$$uv = B, \quad uw = n, \quad vw = h, \quad uvw = 90^\circ, \quad vuw = \zeta,$$

whence

$$\left.\begin{aligned} \tan h &= \tan \zeta \sin B, \\ \tan B &= \tan n \cos \zeta, \\ \cos n &= \cos B \cos h, \end{aligned}\right\} \quad (1)$$

or if we prefer to introduce the descending node and the inclination of the orbit, that is to say, if we write $h = \text{☋} - L$, and the angle $uwv = i$, then

$$\left.\begin{aligned} \tan(\text{☋} - L) &= \tan \zeta \sin B, \\ \tan i &= \frac{\tan B}{\sin(\text{☋} - L)}, \\ \cos i &= \cos B \sin \zeta. \end{aligned}\right\} \quad (2)$$

Secondly, we shall have for the excentricity of the orbit e, for its parameter p, and for the perihelion distance q, the general formulæ

$$\left.\begin{aligned} e^2 - 1 &= \frac{c^2}{\mu^2}\left(V^2 - 2\frac{\mu}{R}\right) = \frac{c^2}{\mu^2}\left[V^2 - 2\frac{\mu}{A}\left(1 + \frac{s^2}{A^2}\right)^{-\frac{1}{2}}\right], \\ p &= q(1 + e) = \frac{c^2}{\mu}, \end{aligned}\right\} \quad (3)$$

where we have

V, the initial velocity,
μ, the constant of solar attraction (the k^2 of Gauss),
$\frac{1}{2}c$, the area described by the radius vector in the unity of time ($c = Vs$),
R, the initial distance SW_1, $= \sqrt{A^2 + s}$.

Let us now admit that for the corpuscule passing through U, that is, for which $s = 0$, the velocity is that in a parabola, consequently $e = 0$, and the formula (3) will give

$$V^2 = 2\frac{\mu}{A}, \tag{4}$$

In this case all the other corpuscules will describe hyperbolas, but we may say that all these orbits will not sensibly differ from parabolas, so long as we only occupy ourselves with the meteors which meet the orbit of the Earth. In fact, this restriction gives $q \leqq 1$, and since from the formulæ (3) and (4)

$$e - 1 = q\frac{2}{A}\left(\frac{1}{2}\frac{s^2}{A^2} - \frac{3}{8}\frac{s^4}{A^4} + \ldots\right) = \frac{q}{A}\frac{s^2}{A^2}\left(1 - \frac{3}{4}\frac{s^2}{A^2} + \ldots\right), \tag{5}$$

the excess of e above unity is a very small quantity. In order to calculate it, we then have with a close approximation, from (3) and (4),

$$2q = \frac{V^2 s^2}{\mu} = 2\frac{s^2}{A}, \tag{6}$$

which gives for the formula (5)

$$e - 1 = \left(\frac{q}{A}\right)^2\left(1 - \frac{3}{4}\frac{q}{A} + \ldots\right), \tag{7}$$

that is to say, that for $q = 1$, $A = 10000$, the excentricity will not sensibly differ from unity, and consequently q will not sensibly differ from the value given by the formula (6).

Lastly, the angle M between the axis and the asymptote will be very approximately given by the equation,

$$\tan M = \sqrt{e^2 - 1} = \sqrt{2(e - 1)} = \frac{q}{A}\sqrt{2}. \tag{8}$$

so that, according to the foregoing suppositions, we shall have $M = 29''$, a quantity which may be neglected.

We shall therefore consider each molecule as describing a parabola the perihelion distance of which is given by the formula (6), and the axis of which coincides with the line S U.

It remains to inquire what is the geometric locus in the plane P P′ of all the points W_1 through which pass the molecules which afterwards meet the terrestrial orbit.

We have for the orbit of each molecule

$$r(1 + \cos v) = 2\frac{s^2}{A}, \tag{9}$$

or introducing the relations $r = 1$, $v = 180° + n$, this becomes

$$1 - \cos n = 1 - \cos h \cos B = 2\frac{s^2}{A}, \qquad (10)$$

whence from the formulæ (10) and (1)

$$\cos^2 n\,(1 + \tan^2 n) = 1 = \left(2\frac{s^2}{A} - 1\right)^2 \left(1 + \frac{\tan^2 B}{\cos^2 \zeta}\right), \qquad (11)$$

the equation of the required curve in the polar co-ordinates s and ζ. To obtain it in rectangular co-ordinates, we may write $s^2 = x^2 + y^2$ and $\frac{1}{\cos \zeta} = \frac{s}{x}$, so that the line U V has in fact been chosen for the axis of x. This gives

$$4x^4 + 4x^2y^2(1 + \sin^2 B) + 4y^4 \sin^2 B - 4Ax^2 - 4Ay^2 \sin^2 B + A^2 \sin^2 B = 0$$

a curve which is symmetric in regard to each axis.

For $y = 0$ the equation gives

$$x_1 = \pm\sqrt{\frac{1}{2}A(1 + \cos B)}, \quad x_2 = \mp\sqrt{A(1 - \cos B)},$$

where the upper signs belong to the corpuscules which, as they cut the orbit of the Earth, are in their descending node; the lower signs to those which only cut the Earth's orbit after they have gone round the Sun and arrived at the ascending node.

For $x = c$, the equation gives $y = \pm\sqrt{\frac{1}{2}A}$,

" $B = 90°$ " $x^2 + y^2 = \frac{1}{2}A$,

" $B = 0$ " $x^3 = 0$ and $x^2 + y^2 = A$.

that is to say, the line P C, and a circle having its centre on this line. In the latter case $q = 1$, and from the formula (10), $\cos h = -1$, which are co-ordinates of the perihelion common to all the orbits which pass through any point of the circle.

§ 2. What is the density of the swarm at any point of the Earth's orbit, taking for unity the density in the neighbourhood of the plane P P′?

To answer this question let us follow the motions of the eight molecules, the initial positions of which at the same instant were expressed by the co-ordinates,

No. 1. by $(s, \quad \zeta, \quad A)$,
2. „ $(s, \quad \zeta + d\zeta, \quad A)$,
3. „ $(s + ds, \quad \zeta, \quad A)$,
4. „ $(s + ds, \quad \zeta + d\zeta, \quad A)$,
5. „ $(s, \quad \zeta, \quad A + dA)$,
6. „ $(s, \quad \zeta + d\zeta, \quad A + dA)$,
7. „ $(s + ds, \quad \zeta, \quad A + dA)$,
8. „ $(s + ds, \quad \zeta + d\zeta, \quad A + dA)$.

Originally they formed a rectangular parallelopiped of the volume $ds \times s\,d\zeta \times dA$. We have to find the volume comprised between the positions when they have arrived near the terrestrial orbit.

Everything being symmetrical about the line S U, it at once appears that Nos. 1 and 2 will arrive at the same instant at the points w_1 and w_2 of the sphere radius unity described about the Sun, and that $uw_1 = uw_2$ (fig. 2), Nos. 3 and 4 will arrive a little later at w_3 and w_4; Nos. 5 to 8 will follow the others at a distance sensibly constant for all these numbers.

The calculation may be conducted in two manners.

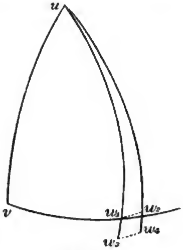

Fig. 2.

I. We may consider first what happens in the plane uw_1w_3, and multiply by w_1w_2 the area of the parallelogram formed by the Nos. 1, 3, 5, and 7 (fig. 3). At the moment that No. 1 arrives at τ_1 at the distance 1 from the Sun, the others will be at τ_3, τ_5 and τ_7.

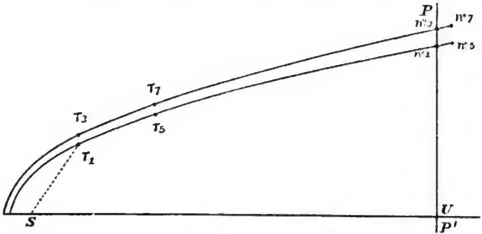

Fig. 3.

The primitive velocity being $\sqrt{\frac{2\mu}{A}}$, that at the distance 1 $=\sqrt{2\mu}$, we have

$$dA = \sqrt{\frac{2\mu}{A}}\,dt, \qquad \tau_1\tau_5 = \sqrt{2\mu}\,dt = \sqrt{A}\,dA. \qquad (13)$$

The equation $y^2 = p^2 + 2px$ of the parabola $\tau_1 \tau_5$ for the origin S then gives for the distance of the two neighbouring parabolas measured in a direction parallel to the axis of y,

$$dy = \frac{p + x}{g}\, dp = \frac{r}{y}\, dp,$$

whence writing $r = 1$, $y = \sin n$, for the distance of the two parabolas $\tau_1 \tau_5$ and $\tau_3 \tau_7$, we have

$$dy \cos\frac{1}{2}n = \frac{dp}{2\sin\frac{1}{2}n} = \frac{dy}{\sin\frac{1}{2}n} = \frac{2\,s\,ds}{A\sin\frac{1}{2}n}. \qquad (14)$$

The parallelogram $\tau_1\,\tau_3\,\tau_7\,\tau_5$, has, therefore, a surface

$$\tau_1\,\tau_5 \times dy\cos\frac{1}{2}n = \frac{2\,s\,ds\,dA}{\sin\frac{1}{2}n\,\sqrt{A}}, \qquad (15)$$

and in a different plane the Nos. 2, 4, 6, 8, will have perfectly similar positions, and will form a parallelogram of the same shape and dimensions.

Finally, in figure 2,

$$w_1\,w_2 = w_3\,w_4 = \sin n\, d\zeta, \qquad (16)$$

whence the volume comprised between the eight molecules when they arrive at the terrestrial orbit is

$$\frac{4\cos\frac{1}{2}n}{\sqrt{A}} ds \,.\, s\,d\zeta \,.\, dA,$$

and the density is thus

$$D = \frac{\sqrt{A}}{4\cos\frac{1}{2}n}. \qquad (17)$$

II. We may diminish the co-ordinate A of Nos. 3 and 4 by a certain quantity so chosen that they arrive at the distance 1 from the Sun simultaneously with Nos. 1 and 2. Doing the same thing for the co-ordinate $A + dA$ of Nos. 7 and 8, the primitive parallelopiped will have changed its form, preserving a constant volume.

In this case Nos. 5 to 8 will be at a distance $1 + dr$ from the Sun at the instant when Nos. 1 to 4 have reached the sphere radius 1. We have, therefore, to multiply the surface $w_1\,w_2\,w_3\,w_4$, by dr.

We have already

$$w_1 w_2 = \sin n \, d\zeta, \qquad (16)$$

and, differentiating the formula (10),

$$w_1 w_3 = d n = \frac{4 s \, d s}{\mathrm{A} \sin n}. \qquad (18)$$

It remains to find $d r$. The general formulæ

$$r^2 d v = \sqrt{p \mu} \, d t,$$

$$r = \frac{p}{1 + e \cos v}, \text{ with its differential } \quad d r = \frac{r^2}{p} e \sin v \, d v,$$

give

$$r d r = \sqrt{(e^2 - 1) \, r^2 + 2 p r - p^2} \sqrt{\frac{\mu}{p}} \, d t. \qquad (19)$$

Hence, in our case where $e = 1$, $p = 2 q$, we have

$$r d r = \sqrt{r - q} \sqrt{2 \mu} \, d t.$$

and, considering $d t$ as a constant quantity,

$$r d r = \sqrt{\frac{r - q}{\mathrm{R} - q}} \, \mathrm{R} \, d \mathrm{R}, \qquad (20)$$

a formula which for $\mathrm{R} = 1$, $\mathrm{R} \, d \mathrm{R} = \mathrm{A} \, d \mathrm{A}$, gives

$$d r = \sqrt{\frac{1 - q}{\mathrm{R} - q}} \, \mathrm{A} \, d \mathrm{A},$$

or with a very close approximation

$$d r = \mathrm{A} \, d \mathrm{A} \sqrt{\frac{1 - q}{\mathrm{A} - \frac{1}{2} q}} = \sqrt{\mathrm{A} (1 - q)} \, d \mathrm{A},$$

the volume comprised between the eight molecules becomes therefore

$$w_1 w_2 \times w_1 w_3 \times d r = 4 \sqrt{\frac{1 - q}{\mathrm{A}}} \, d s \, . \, s \, d \zeta \, . \, d \mathrm{A},$$

and the required density, as before

$$\mathrm{D} = \frac{1}{4} \sqrt{\frac{\mathrm{A}}{1 - q}} = \frac{\sqrt{\mathrm{A}}}{4 \cos \frac{1}{2} n}.$$

It is to be remarked that D is the real density. The apparent density, or number of meteors which fall during a certain time, will depend not only on D, but also on their relative velocity in regard to the Earth, and on the perturbations which this planet produces in their movements.

The following table, calculated from the formulæ (1) and (17) for B = 51° 30′ and for successive values of h, gives an *aperçu* of the densities of different parts of the same swarm at the moment when they meet the orbit of the Earth. The density is taken to be 1 for A = 10000.

h	n		D	
°	°	′	°	′
± 0	51	30	27	7
± 15	53	3	27	9
± 30	57	23	28	5
± 45	63	53	29	5
± 60	71	52	30	9
± 75	80	44	32	8
± 90	90	0	35	3
± 105	99	16	38	6
± 120	108	8	42	6
± 135	116	7	47	2
± 150	122	37	52	2
± 175	126	57	56	0
± 180	128	30	57	5

§ 3. What is the radiant point which the swarm will present at any point of the Earth's orbit ?

It appears, in the first place, that at every instant there exist two of these points, one of them for the meteors which are at their descending node, the other for those which, having attained their ascending node, have the same velocity but in a directly contrary direction. The two may be calculated successively.

For this purpose it is to be remembered that every tangent to a parabola divides into two equal parts the angle formed by the radius vector and the diameter produced.

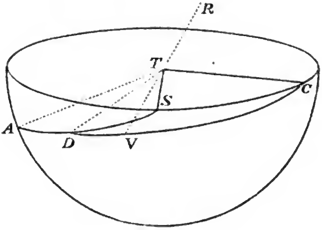

Fig. 4.

Suppose, then, fig. 4, that T is the Earth, occupying the centre of a sphere whereon A denotes the point opposite to V; that is to say, that T A is taken in space parallel to the line S U. Let S be the Sun, D a point dividing the arc A S into two equal parts; the meteor, as it meets the Earth, will have the direction T D, and, we may add, the velocity $\sqrt{2\mu}$. Hence, taking the arc S C = 90°, T C will be the direction of the motion of the Earth taken in the inverse sense. Whence it follows that a parallelogram constructed on the lines T C and T D with the lengths $\sqrt{\mu}$ and $\sqrt{2\mu}$ will give, by its diagonal, the relative motion of the meteors in direction and magnitude. This diagonal, situate in the plane D T C, will cut the sphere somewhere in V. Thus the point V will be opposite to the radiant point R.

For the calculation, we shall unite the points A, D, S, C, and V with the north pole P, and express their position in longitude and polar distance.

Taking l for the longitude of the Earth, seen from the Sun, we shall have

For	A	longitude	$180^\circ + L$	Polar Dist.	$= P = 90^\circ + B$
,,	S	,,	$180 + l$		$= 90^\circ$
,,	C	,,	$270 + l$		$= 90$
,,	D	,,	$180 + L + \lambda_1$		$= \pi_1$
,,	V	,,	$180 + L + \lambda_2$		$= \pi_2$
,,	R	,,	$l + \lambda_2$		$= 180 - \pi_2$

we write moreover D C = H, D V = α, and A S = n = arc $u\,w$ of figure 1.

In order to facilitate the calculation, let us represent a spherical triangle M N O (fig. 5), divided into two parts by an arc of great circle N P. Let $\Phi + \Psi = N$, $\varphi + \psi = n$, $m = 90^\circ$, we shall have, equating the values of sin O and of cos O derived successively from the triangles N O P and N O M,

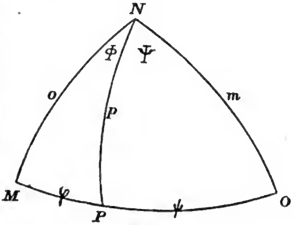

Fig. 5.

$$\sin p = \sin o \frac{\sin\psi}{\sin\Psi}\,\frac{\sin N}{\sin n}, \quad \cos p = \cos o\,\frac{\sin\psi}{\sin N}, \quad (22) \text{ and } (23)$$

$$\tan p = \tan o\,\frac{\sin N}{\sin\Psi}, \qquad (24)$$

$$\sin p \sin\Psi = \sin o \sin\psi\,\frac{\sin N}{\sin n}, \quad \sin p \cos\Psi = \cos\psi, \qquad (22) \text{ and } (25)$$

$$\tan \Psi = \tan \psi \sin o \frac{\sin N}{\sin n}, \qquad (26)$$

$$\cos n = \sin o \cos N. \qquad (27)$$

Applying to the triangle A P S the formulæ (22), (24), (26), 27), we have

$$n = n,\ \varphi = \psi = \frac{1}{2} n,\ o = P,\ p = \pi_1,\ N = l - L,\ \Psi = l - L - \lambda_1,$$

whence

$$\sin \pi_1 = \frac{\sin P \sin (l - L)}{2 \cos \frac{1}{2} n \sin (l - L - \lambda_1)},\ \tan \pi_1 = \tan P \frac{\sin (l - L)}{\sin (l - L - \lambda_1)},$$

(28) and (29)

$$\tan (l - L - \lambda_1) = \frac{\sin P \sin (l - L)}{2 \cos^2 \frac{1}{2} n},\ \cos n = \sin P \cos (l - L).$$

(30) and (31)

Applying next to the triangle D P C the formulæ (24), (26), and (27), we have

$$n = H,\ \varphi = \alpha,\ \psi = H - \alpha,\ o = \pi_1,\ p = \pi_2,\ N = 90° + l - L - \lambda_1,\ \psi = 90° - \lambda_2,$$

whence

$$\tan \pi_2 = \tan \pi_1 \frac{\cos (l - L - \lambda_1)}{\cos \lambda_2},\ \cot \lambda_2 = \frac{\tan (H - \alpha)}{\sin H} \sin \pi_1 \cos (l - L - \lambda_1),$$

(32) and (33)

$$\cos H = -\sin \pi_1 \sin (l - L - \lambda_1). \qquad (34)$$

The formulæ (28), (30), and (33), give

$$\tan \lambda_2 = \frac{\sin H \cot (H - \alpha)}{\cos \frac{1}{2} n}, \qquad (35)$$

the formulæ (29), (30), and (32),

$$\tan \pi_2 = \frac{2 \cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2}, \qquad (36)$$

the formulæ (28) and (34),

$$\cos H = -\frac{\sin P \sin (l - L)}{2 \cos \frac{1}{2} n}, \tag{37}$$

and the problem will thus be resolved as soon as we know the value of cot $(H - \alpha)$ To calculate it, we have in a rectilinear triangle, the half of the parallelogram of the motions,

Angles α, $H - \alpha$, and $180° - H$.

Corresponding sides $\sqrt{\mu}$, $\sqrt{2\mu}$, and $\sqrt{(3 + 2\sqrt{2} \cos H)\mu}$,

whence

$$\frac{\sin^2 H}{\sin^2 (H - \alpha)} = \frac{3 + 2\sqrt{2} \cos H}{2}, \quad \cos^2 (H - \alpha) = \frac{(1 + \sqrt{2} \cos H)^2}{3 + 2\sqrt{2} \cos H},$$

$$\sin H \cot (H - \alpha) = \frac{1 + \sqrt{2} \cos H}{\sqrt{2}} = \cos 45° + \cos H. \tag{38}$$

To resume, the system of formulæ necessary for the calculation is

$$\left.\begin{aligned}
&\cos n = \sin P \cos (l - L),\\
&2 \cos \frac{1}{2} n \cos H = -\sin P \sin (l - L),\\
&\tan \lambda_2 = \frac{\cos 45° + \cos H}{\cos \frac{1}{2} n}, \quad \tan \pi_2 = \frac{2 \cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2},\\
&\text{longitude of R} = l + \lambda_2,\\
&\text{N. latitude of R} = \pi_2 - 90°,
\end{aligned}\right\} \tag{39}$$

In the second place, we have to occupy ourselves with the second radiant point belonging to the meteors which are at the ascending node. In this case, taking (fig. 6) U for the point

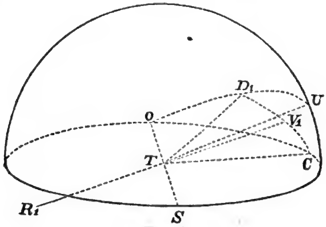

Fig. 6.

opposite to A, and O for that opposite to S, let D_1 be the point situate at the middle of the arc UO, and V_1 the point marked on the sphere by the diagonal of the parallelogram constructed on the lines TD_1 and TC. We have for

for U,	longitude	$= L$	polar distance		$= 180° - P$
,, O	,,	$= l$	,,	,,	90
,, C	,,	$= l - 90°$	,,	,,	90
,, D_1	,,	$= L + \lambda_1$	,,	,,	π_1
,, V_1	,,	$= l - \lambda_2$	,,	,,	π_2
,, R_1	,,	$= 180° + l - \lambda_2$	,,	,,	$180 - \pi_2$

and then

$$D_1C = H, \quad D_1V_1 = \alpha, \quad OU = n,$$

and the repetition of the calculation gives

$$\left.\begin{aligned}
\cos n &= \sin P \cos (l - L), \\
2 \cos \frac{1}{2} \cos H &= \sin P \sin (l - L), \\
\tan \lambda_2 &= \frac{\cos 45° + \cos H}{\cos \frac{1}{2} n}, \quad \tan \pi_2 = -\frac{2 \cos^2 \frac{1}{2} n}{\cos P \cos \lambda_2}, \\
\text{Longitude of } R_1 &= 180° + l - \lambda_2, \\
\text{N. latitude of } R_1 &= \pi_2 - 90°.
\end{aligned}\right\} \tag{40}$$

Hence, introducing the longitude of the Sun $= \odot$, the latitude of the point $U = B_1$, that of the point $R = \beta_2$, and uniting the formulæ for the two cases, we have

$$\left.\begin{aligned}
\cos n &= - \cos B \cos (\odot - L), \\
\cos H &= \frac{\cos B \sin (\odot - L)}{2 \cos \frac{1}{2} n}, \\
\tan \lambda_2 &= \frac{\cos 45° \pm \cos H}{\cos \frac{1}{2} n}, \quad \tan \beta_2 = \pm \frac{\sin B \cos \lambda_2}{2 \cos^2 \frac{1}{2} n}, \\
\text{Long. of } R &= 180° + \odot + \lambda_2 = \odot - \lambda_2, \\
\text{N. lat. of } R &= \beta_2,
\end{aligned}\right\} \tag{41}$$

where the upper signs belong to the meteors at the descending node, the lower ones to those at the ascending node.

The knowledge of the relative motion is a great step in advance towards finding the apparent density of the rain of meteors.

This will be proportional to

$$D\sqrt{(3+2\sqrt{2}\cos H)\,\mu} = \frac{\sqrt{A\mu}}{4\cos\frac{1}{2}n}\sqrt{3 \pm \frac{1.4\cos\beta\sin(\odot - L)}{\cos\frac{1}{2}n}} \quad (42)$$

on the supposition that the attraction of the Earth has no influence on the motion of the corpuscules. But this action being sometimes very sensible, it follows that the formula (42) gives only a first approximation to the apparent density.

The following table, calculated from the formula (41), where U is taken to be the radiant point of the Comets of 1857 and 1867, will show how considerable are the annual variations of the radiant points. With $L = 72°\,45'$, $B = -51°\,30'$, I find

				The Point R.		The Point R_1.	
Date.	$\odot$	n.	H.	Long.	Lat.	Long.	Lat.
	°	° ′	° ′	° ′	° ′	° ′	° ′
Dec. 4	252 45	51 30	90 0	110 53	−20 46	214 37	+20 46
Jan. 3	282 45	57 23	100 13	133 53	−23 32	237 31	+19 42
Feb. 2	312 45	71 52	109 26	157 33	−28 26	260 40	+20 8
Mar. 3	342 45	90 0	116 7	183 26	−36 13	284 24	+22 [illegible]
Apr. 2	12 45	108 8	117 20	215 39	−46 19	309 27	+27 3
May 3	42 45	122 37	108 55	261 20	−53 0	337 43	+35 36
June 3	72 45	128 30	90 0	311 11	−47 21	14 19	+47 21
July 4	102 45	122 37	71 5	347 47	−35 36	64 10	+53 0
Aug. 5	132 45	108 8	62 40	16 3	−27 3	109 51	+46 19
Sept. 4	162 45	90 0	63 53	41 6	−22 19	142 4	+36 13
Oct. 5	192 45	71 52	70 34	64 50	−20 8	168 57	+28 26
Nov. 4	222 45	57 23	79 47	87 59	−19 42	191 37	+23 32

§ 4. In the last place, we proceed to calculate the influence of the attraction of the Earth on the density of the rain of meteors, and on the position of the radiant point.

The relative velocity $\sqrt{(3 + 2\sqrt{2}\cos H)\,\mu}$ has a minimum for $H = 180°$, and the value is then $= 0{\cdot}414\sqrt{\mu}$. With this minimum velocity the meteors will describe hyperbolic orbits round the centre of the Earth. In fact, admitting for a moment that one day before their fall they have not yet undergone any attraction from the Earth, they will then be at a distance $= 0{\cdot}414\sqrt{\mu}$ unities, and we shall have $V^2 > \frac{2g}{r}$, that is, in numbers

$$(0{\cdot}414)^2\mu > \frac{2\mu}{319455} \times \frac{1}{0{\cdot}414\sqrt{\mu}} \quad \text{or} \quad (0{\cdot}414)^2 > 0{\cdot}00879.$$

This inequality would be still greater if we had introduced the attraction of the Earth during the preceding days, and the hyperbolic character of the orbit would have become still more marked. Having then established it for the smallest angular velocity, we have in fact established it for all the meteors which the Earth meets during its annual revolution.

We may therefore resume the reasonings of §§ 1 and 2. Only we must in figure 1 replace the point S by the Earth, the point U by the radiant point R_1, the parabolic orbit of each molecule by a hyperbolic orbit. We may take for the plane PP' a plane normal to the asymptotes (parallel to each other) of all the hyperbolas. Lastly, we have to consider the relative velocity V as belonging to an infinite distance, which gives for the dimensions of the orbits

$$\left.\begin{aligned} &p = q\,(e+1) = a\,(e^2-1) = \frac{V^2 s^2}{g},\ e^2 = 1 + \frac{V^4 s^2}{g^2}, \\ &a = \frac{g}{V^2}, \quad \tan M = \frac{V^2 s}{g} = \frac{s}{a}, \quad \cos M = \frac{1}{e},\ \sin M = \frac{s}{a e}, \end{aligned}\right\} \qquad (43)$$

where p, q, e, s, and M signify, as in §§ 1 and 2, a is the semi-axis major, and g the constant of terrestrial attraction.

The total deviation undergone, in consequence of this attraction, by a meteor which passes near the Earth will thus be $180^\circ - 2\,M = 2\,\delta$, so that we shall have

$$\tan \delta = \cot M = \frac{g}{V^2 s}, \qquad (44)$$

where δ will be larger as s is smaller.

What is then the value of δ for a meteor which grazes the surface of the Earth?

The formulæ (43) give

$$e + 1 = \frac{V^2 s^2}{g\,q},\ e - 1 = \frac{V^2}{g}\,q,\quad 2 = \frac{V^2}{g}\left(\frac{s^2}{q} - q\right), \qquad (45)$$

and for $q = 1$,

$$s^2 = 1 + 2\,\frac{g}{V^2},\quad \tan \delta = \frac{g}{V^2}\left(1 + 2\,\frac{g}{V^2}\right)^{-\frac{1}{2}}. \qquad (46)$$

In the numerical calculations to be based upon these formulæ, it would be necessary to pay attention to reduce g and V to the new unity which has just been introduced. In fact, instead of the radius of the terrestrial orbit, we have taken as unity of distance the radius of the Earth; we must therefore, if π be the parallax of the Sun, write

$$g = \frac{\mu}{319455}\,(\cot \pi)^3, \qquad V^2 = (3 + 2\,\sqrt{2}\cos H)\,\mu \cot^2 \pi,$$

or, for $\pi = 8''{\cdot}916$,

$$\frac{g}{V^2} = \frac{0{\cdot}07241}{(3 + 2\sqrt{2})\cos H}.$$

The following are some values calculated by means of the formulæ (46) and (47):—

H.	$\frac{g}{V^2}$	s^2	∂.
0°	0·0124	1·025	0° 42′
45	0·0145	1·029	0 49
90	0·0241	1·048	1 21
135	0·0724	1·145	3 52
180	0·4217	1·843	17 15

In this table ∂ is the perturbation undergone by the radiant point when observed at the horizon. Nearer the zenith this perturbation is less considerable, and at the zenith it is zero.

The value of s^2 indicates in what proportion the attraction of the Earth, in deviating the meteors, multiplies the number of them which fall upon the Earth.

Let us first pursue the latter inquiry, and see what is the density of the swarm at a place on the Earth situate at n' degrees of distance from the place which has the radiant point at its zenith.

Consider, again, a parallelopiped in the vicinity of the plane P P′ and of the volume $ds \times s\,d\zeta \times dA$.

The formula (16) gives

$$w_1\,w_2 = \sin n'\,.\,d\zeta.$$

Then differentiating the formula

$$p = 1 - e\cos(M + n') = 1 - \cos n' + \sin n' \tan M, \qquad (48)$$

which is the formula for the hyperbola, r being put $= 1$; and substituting the values derived from the formulæ (43),

$$dp = \frac{V^2}{g}\,2\,s\,ds, \quad d\,.\tan M = \frac{V^2}{g}\,ds,$$

we obtain

$$w_1 w_3 = dn' = \frac{V^2}{g}\,\frac{2\,s - \sin n'}{\sin n' + \cos n' \tan M}\,ds, \qquad (49)$$

Lastly, the formula (19) for $r = 1$ gives by means of the formulæ (43) and with the relation $V\,dt = dA$,

$$dr = \sqrt{1 - s^2 + \frac{2\,g}{V^2}}\,.\,dA. \qquad (50)$$

The volume of the parallelopiped at the instant of the fall will therefore be

$$w_1 w_2 \times w_1 w_3 \times dr = (2s - \sin n') \sin n' \frac{V^2}{g} \frac{\sqrt{1 - s^2 + \frac{2g}{V^2}}}{\sin n' + \cos n' \tan M} d\zeta \times ds \times dA,$$

and since, by virtue of the formulæ (48) and (43),

$$\sin n' + \cos n' \tan M = \frac{V^2 s}{g} \sqrt{1 - s^2 + \frac{2g}{V^2}}, \qquad (51)$$

we may say that the effect of the attraction of the Earth is to multiply the density of the swarm by a factor

$$f = \frac{s^2}{\sin n' (2s - \sin n')}. \qquad (52)$$

Let us apply to this case the other process of § 2, which consists in calculating in the first instance the parallelogram formed by the Nos. 1, 3, 5, and 7.

We have for the equation of the orbit expressed in rectangular co-ordinates, with the centre of the Earth as origin, and with the axes of x parallel to the asymptote,

$$x^2 + y^2 = (p + x - y \tan M)^2,$$

and differentiating with respect to y, p, and M, and then putting $r = 1$, $x = \cos n'$, $y = \sin n'$, we find

$$dy = \frac{dp - \sin n' \, d.\tan M}{\sin n' + \tan M} = \frac{V^2}{g} \frac{2s - \sin n'}{\sin n' + \tan M} ds, \qquad (53)$$

Differentiating then the same formula with respect to x and y, we have for the same values of r, x, and y,

$$\tan \alpha_1 = \frac{dy}{dx} = \frac{1 - \cos n'}{\sin n' + \tan M},$$

whence for the distance of the two orbits $\tau_1 \tau_5$ and $\tau_3 \tau_7$

$$dy \cos \alpha_1 = \frac{V^2}{g} \frac{2s - \sin n'}{\sqrt{2p + \tan^2 M}} ds = \frac{2s - \sin n'}{s \sqrt{1 + \frac{2g}{V^2}}} ds, \qquad (55)$$

To have the base $\tau_1 \tau_5$ of the parallelogram, we may remark that the primitive velocity is V, and that for the unity of distance is $\sqrt{V^2 + 2g}$; whence

$$dA' = V\,dt, \quad \tau_1 \tau_5 = \sqrt{V^2 + 2g} \,.\, dt = \sqrt{1 + \frac{2g}{V^2}} dA, \qquad (56)$$

and applying, lastly, the known value of $w_1\, w_2$ we shall have for the volume of the parallelopiped at the moment of the fall

$$\frac{1}{s}(2s - \sin n')\sin n'.\ d\zeta\ dA\ ds$$

which leads again to the formula (52).

Let us remark that this formula, for $s = 0$, and consequently $n' = 0$, gives $f = \frac{0}{0}$, an expression of which the value is easily determined. For n' indefinitely small the formula (48) gives

$$\sin n' = \frac{p}{\tan M} = s,$$

and thence

$$f = \frac{s^2}{s^2} = 1.$$

The limit of the places on the Earth which receive the rain of meteors is determined for the value of s^2 in the formula (46) for which (51) gives

$$\sin n' + \cos n' \tan M = 0,\ n' + M = 180^\circ.$$

But from the formula (43)

$$e = \frac{V^2 + g}{g},\ \sin^2 M = \frac{V^2(V^2 + 2g)}{(V^2 + g)^2},\ s \sin M = \frac{V^2 + 2g}{V^2 + g},$$

whence for f in this limiting case

$$f = \frac{(V^2 + g)^2}{V^2(V^2 + 2g)} = 1 + \frac{g^2}{V^2(V^2 + 2g)},$$

a quantity which in general will not differ sensibly from unity.

The last method has a particular advantage in that it gives us in the formula (54) an expression for the angle α_1 between the

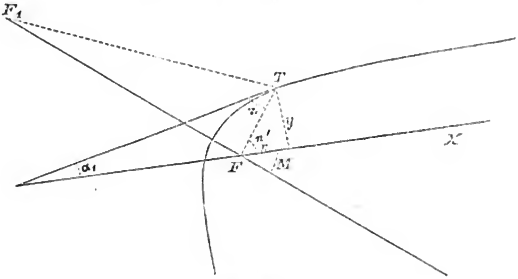

Fig. 7.

asymptote and the direction of motion at the instant of the fall (fig. 7). This angle is therefore the perturbation undergone by the radiant point for a place on the Earth determined by the angle n'. It will be preferable to express this perturbation as a function of z, the zenith distance of the observed radiant point. Introducing for this purpose the relation $n' = z + \alpha$, the formula (54) becomes

$$\cos z \cos \mathrm{M} = \cos (\alpha_1 + \mathrm{M}), \tag{57}$$

or, replacing M by δ it is

$$\cos z \sin \delta = \sin (\delta - \alpha_1), \tag{58}$$

where the value of δ is give by the formula (44).

We may therefore calculate the perturbation α_1 as soon as we have a relation between z and s_1, a relation which is found in the following manner. Connecting, in fig. 7, the point T with the points F and F_1 we have a triangle the sides of which are 1, $2a + 1$, and $2ae$, and in which the angle opposite to the last-mentioned side is $= 2z$. We have therefore

$$\sin^2 z = \frac{a^2 (e^2 - 1)}{2a + 1} = \frac{ap}{2a + 1} = \frac{s^2}{1 + 2\frac{g}{\mathrm{V}^2}}. \tag{59}$$

To recapitulate we may calculate the correction α_1 of an observed z by the formula

$$s = \sin z \sqrt{1 + \frac{2g}{\mathrm{V}^2}}, \ \tan \delta = \frac{g}{\mathrm{V}^2 s}, \ \sin(\delta - \alpha_1) = \sin \delta \cos z, \tag{60}$$

which will serve equally well in the case of an observed s, to calculate successively z, δ and α_1.

For $z = 0$ the formula (60) gives $\alpha_1 = 0$; for $z = 90°$ we have first the formulæ (46) and then $\alpha_1 = \delta$.

The following table gives some values of α_1, for the case $\mathrm{H} = 180°$, that is, $\frac{g}{\mathrm{V}^2} = 0{\cdot}3809$.

z	s	δ	$\delta - \alpha_1$	α_1
°		° ′	° ′	° ′
0	0·0000	90 0	90 0	0 0
15	0·3514	50 12	47 54	2 18
30	0·6788	31 15	27 12	4 39
45	0·9600	23 43	16 32	7 11
60	1·176	19 44	9 43	10 1
75	1·311	17 50	4 33	13 17
90	1·358	17 15	0 0	17 15

I have added a table of some values of f, on the same supposition as to the value of H, calculated by the formulæ

$$a = \frac{g}{\mathrm{V}^2}, \ \tan \mathrm{M} = \frac{s}{a}, \ p = \frac{s^2}{a}, \ \cos (\mathrm{M} + n') = (1 - p) \cos \mathrm{M},$$

$$f = \frac{s^2}{\sin n' (2s - \sin n')}.$$

z	s	M		M + n'		f
°		°	′	°	′	
0	0·0000	0	0	0	0	1·00
15	0·3514	39	48	57	6	1·02
30	0·6788	58	9	92	46	1·03
45	0·6900	66	17	118	29	1·03
20	1·176	70	17	140	13	1·04
75	1·311	72	10	160	25	1·06
90	1·358	72	45	180	0	1·10

§ 5. The preceding paragraphs give the principal features which characterise the phenomenon of a meteoric shower continuing during a year.

In § 3 we have seen how necessary it is to take account of the annual variations presented by the radiant point. Probably it is a less exact proceeding to consider these points as constant during a fortnight or even during two months, as is done in Mr. Greg's chart.

The general formulæ of this paragraph allow us to decide two questions relating to the theory of falling stars.

In the first place, we may ask if the cometary systems contain members of an inferior density, which resolve themselves in our neighbourhood, so as to form there currents of isolated particles. The points of the sphere I. to VII., which I have noticed in vol. xxvii. of the *Monthly Notices*, may be identified in this investigation with the point U of paragraphs 1 and 2.

This calculation has already been made, as an example of the application of the formulæ (41) for the point IV., which is one of those best determined. In comparing the results to the chart, in which Mr. Greg has put a total of 56 radiant points, I find that there are two of these points which may perhaps have the same origin as the Comets of 1857 and 1867.

There is first, point 27, indicated in the following mannor:—

May 29 to June 17 $\alpha = 336°$, $\delta = 45°$,
from whence follows $\lambda = 2°$, $\beta = 49°$,

whilst the table given at the end of § 3 indicates for the same interval points R_1 varying between the limits

$\lambda = 8°$, $\beta = 45°$,
and $\lambda = 39°$, $\beta = 50°$,

and we have, moreover, the point 48,

Oct. 18 to Nov. 3 $\alpha = 83°$, $\delta = 12°$,
$\lambda = 83°$, $\beta = -11°$,

whilst the before-mentioned table gives for the same interval points R situated between

$$\lambda = 76^\circ, \quad \beta = -20^\circ,$$
$$\lambda = 88^\circ, \quad \beta = -20^\circ.$$

Certainly I am far from considering this first approximation as a decisive proof, but there is one circumstance which perhaps gives it a little more importance. This is that on November 4th, the Earth, as seen from the Sun, has a longitude of 43°, which is the mean longitude of the ascending nodes of the before-mentioned comets; on May 29th, on the contrary, it had a longitude of 248°, which is nearly the direction of the descending node of the Comet 1867, III.

If, then, the coincidence found is more than mere chance, we should say that in November we ought to meet meteors coming direct from Space; in June, meteors which have already passed their perihelion; but all having the same origin as the cometary system of 1857–1867. But this is a point which requires further investigation.

In the second place, it is an important question if, among the radiant points actually known, there are any which belong originally to the same swarm. To answer this, we may calculate the geometric locus upon the sphere of all the radiant points belonging to the same swarm, to the point U of which we give successively the latitudes 0°, 10°, 20°, 90°. We may represent each of these curves in a map, having the pole of the ecliptic for its centre. Then giving to the curve a rotatory motion about this centre, we would easily recognise, in comparing it with the known radiant points, which of these points may have had a common origin.

I propose to apply the formulæ to these two points of investigation.

In § 4 the necessity of taking account of the Earth's attraction becomes apparent. In the most disadvantageous case the apparent radiant point may have sustained a perturbation of more than 17°. This perturbation, although having an origin entirely different, has much resemblance to the atmospheric refraction. It diminishes the zenith distance, and so much the more as this co-ordinate is larger. In future it will be necessary then to note the hour and the minute of each observation made upon a falling star.

It would be unjust not to mention here that M. Schiaparelli has just published an elaborate Memoir entitled *Note e Riflessioni intorno alla Teoria Astronomica delle Stelle cadenti*, a memoir in which he has devoted an ample discussion to the effects of the terrestrial attraction upon the trajectories of meteors. When I received the copy which the illustrious Italian astronomer has done me the honour of sending me, the greater part of my calculation had been already made. I therefore publish them, at the same time acknowledging the priority of the publication by M. Schiaparelli of some results which appear also in the present Memoir.

Utrecht, January 1868.

Additional Identifications of Double Stars in the Synoptic Catalogues of Sir William Herschel's Micrometrical Measurements &c., with a List of Errata. By Sir J. F. W. Herschel, Bart.

Having been engaged since the communication to this Society of my Synoptic Catalogue of my Father's Double Stars, in entering up the measures therein recorded in their places in a general digest of all the recorded measures of all known double stars (a task begun long ago, and which, though I can never look forward to complete, I hope to leave in such a state of forwardness as will perhaps ensure its completion by some other hand), I have been led by the coincidence, or near coincidence, of the measures with those of stars observed by others, taken in conjunction with so near an approximation of place (when reduced to a common epoch) as to make it matter of reasonable probability that the same object has been brought into the field of view in both telescopes, to the identification, more or less probable, of a considerable number of these stars with those subsequently measured. Under the impression that information of this kind cannot but prove interesting to observers engaged in such measurements, and as supplementing the identifications of a similar kind already embodied in the Memoir above mentioned, I here subjoin a list of the objects in question. Among them occur some few whose places could be assigned only by loose approximation from my Father's allineations, but which now can be stated with precision: by which some trouble will be saved to an observer who might otherwise be disappointed by finding it necessary to sweep for some distance round the assigned place of an object before getting it into his field of view.

In the progress of this work I have been led to the detection of a somewhat formidable list of Errata in the printed Catalogue, which I consider it a duty to communicate, apologising, as best I may, for their occurrence, and making the only amends in my power by pointing them out for correction.

Subsequent additional Identifications more or less probable of Double Stars in the Synoptic Catalogues with each other or with objects observed by other Astronomers.

H. I. 11 is also Wr. 136
I. 13 = Σ. 2545* = S. 790
I. 14 *is* 23 *Aquilæ*, as suggested in col. 12 (nisi)
I. 56 = Σ. 178 = P. i. 191

H. I. 63 = S. 778
II. 63 = S. 553
II. 66 = S. 764
II. 70 = S. 734
II. 86 = Σ. 2016

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* I. 13 was assumed as identical with Σ. 2541 on the authority of Struve himself. Mr. Dawes, however, has shown that it is really Σ. 2545: a circumstance which had escaped my recollection; but which is proved to be the fact by the agreement of the measures and the existence of a small companion.

H. II. 97 = S. 775
III. 17 = Sh. 341
III. 37 = Σ. 437 ? ?
III. 38 = Σ. 439 ? ?
III. 46 = III. 114 ?
III. 71 = S. 795
III. 77 = S. 426
III. 80 = S. 412
III. 108 = Sh. 217 *vice* III. 109 ? ?
III. 114 = III. 46 ?
IV. 23 = S. 756 ?
IV. 45 = Sh. 57
IV. 71 = Sh. 324
IV. 92 = S. 759
IV. 127 = Σ. 2434
V. 72 = Sh. 234

H. V. 80 = S. 817
V. 119 = Σ. 734, hardly a doubt.
V. 136 = S. 735
VI. 41 is miscalled by Sh. iv. 41
VI. 87 is miscalled by Sh. vi. 41
H. N. 10 = S. 753
H. N. 11 = Sh. 352
H. N. 13 = Sh. 303
H. N. 33 = Sh. 206
H. N. 36 = Σ. 1466
H. N. 61 = Σ. 1065
H. N. 91 = Σ. 3030 ?
H. N. 105 = Σ. 224 ? ?
H. N. 109 = Sh. 300
H. N. 115 = S. 660 " nova "
H. N. 142 = *Leonis* 339

These identifications, supposing those marked as more or less doubtful (? or ??) verified by future telescopic examinations, will authorize the following more exact places of the stars here numbered in place of those in the Synoptic Catalogue in order of R.A. viz. :—

General No.	Name of Star.	W.H.'s Class and No.	R.A. 1880·0.	Prec. in R.A.	N.P.D. 1880·0	Prec. in N.P.D.	Authority.
			h m s		° ′ ″		
41	Ceti	I. 56	1 45 40·0	+ 3·18	79 46 56	− 17·9	Σ.P.M.
55	Arietis	IV. 105	2 4 21·7	3·22	76 52 46	− 17·1	Σ.P.M.
97	Persei	III. 37	3 36·5	3·74	58 18	− 11·8	Σ.
98	Persei	III. 38	3 37 2·8	3·74	58 14 0	− 11·8	Σ.P.M.
182	Orionis	V. 119	5 27 3·6	3·03	91 48 7	− 2·8	Σ.P.M.
243 } 245 }	Monocerot.	{ III. 46 { III. 114	} 6 35·6	3·30	80 7·0	+ 3·1	(B.A.C.)
499	Serpentis	II. 86	16 6 28·2	2·81	77 46 43	+ 9·6	Σ.P.M.
609	23 Aquilæ	I. 14	19 12 26·1	3·07	89 7 57	− 6·3	B.A.C.
624	Aquilæ	I. 13	19 32 8·1	3·30	100 25 36	− 7·7	Σ.P.M.
805	Piscium	N. 91	23 34 33·5	+ 3·07	91 2 52	− 19·9	Σ.P.M.

Errata in the Synoptic Catalogue.

Page
25. No. 409, *cols.* 6, 7, *for* 3 31·1 | 70 48 | *read* 3 21 ± | 79 15 ± |
78. *In the heading of col.* 1, *for* Class IV., *read* Class V.
90. *In the heading of col.* 1, *for* Class IV., *read* Class VI.

(*In the Synoptic Catalogue by Classes and Numbers.*)

Class. No.
I. 3 *in col.* 6, *for* 348·60, *read* 11·40.
I. 13 „ 12, *insert* Triple. A C = 7 or 8″.

Class.	No.		
I.	60	*in col.*	12, *for* 118°, *read* 5°.
I.	70	,,	12, *for* Wr. 90, *read* Wr. 99.
I.	72	,,	12, *for* S. 133, *read* Sh. 133.
I.	87	,,	5, *before* ·381, *insert* 1802.
I.	96	,,	6, *for* 320·05, *read* 326·05.
II.	11	,,	3, *for* Nov. 19, 1781, *read* Oct. 7, 1779.
II.	13	,,	10, *after* 1780·537, *insert* 4·02 ?
II.	21	,,	12, *for* Σ. 1199, *read* Σ. 1999.
II.	91	,,	3, *for* Sagittarii, *read* Sagittæ.
II.	91	,,	12, *after* P. xix. 322 *insert*, erroneously so called by Struve.
III.	2	,,	4, *for* 1782·753, *read* 1802·753.
III.	7	,,	12, *for* Sh. 215, *read* Sh. 217.
III.	13	,,	1, 2, 12, *for* 5 29·0, *read* 5 29·4; *after* Orionis *insert* 133, *and for* Σ. 745, *read* Σ. 747.
III.	14	,,	1, 2, 12, *for* 5 29·4, *read* 5 29·0; *after* Orionis *dele* 133, *and for* Σ. 747. *read* Σ. 745.
III.	19	,,	6, *for* 182·73, *read* 181·44.
III.	49	,,	10, *for* 17·50, *read* 12·50.
III.	50	,,	6, *for* 340·17, *read* 341·17.
III.	51	,,	10, *after* 1783·003, *insert* 14·69.
III.	55	,,	9, *for* 1783·81, *read* 1783·181.
III.	103	,,	10, 11, *insert in the blank spaces respectively* 12·47 *and* 2.
III.	110	,,	8, *for the lower* A B, *read* A C.
IV.	15	,,	12, *for* Σ. 1674, *read* Σ. 1694.
IV.	22	,,	12, *for* Σ.C.P. 706 = 63 Cygni ? *read* Σ. 2743.
IV.	24	,,	6, *for* 45·68, *read* 314·32.
IV.	77	,,	12, *dele* Sh. 73
IV.	85	,,	4 *for the lower* A B, *read* A D.
IV.	132	,,	12, *dele* H N. 62.
V.	89	,,	8, *for* A C, *read* A B.
V.	97	,,	12, *for* V. 121, *read* VI. 121.
V.	99	,,	12, *for* Σ.C.P. 749, *read* Σ. 2900.
V.	121	,,	12, *dele* For two more probable measures of distance, see V. 97.
V.	122	,,	12, *for* Sh. 119, *read* Sh. 189.
V.	131	,,	12, *for* Σ. 476, *read* Σ.C.P. 476.
VI.	121	,,	12, *insert*, For two more probable measures of distance, see V. 97.
H N.	38	,,	2, *for* 15 35·0, *read* 12 35·0.

(*In the Catalogue in order of R.A.*)

Star Nos.		
75, 76,	*col.*	2, *transfer the letter η from* Arietis *to* Persei.
186, 189,	,,	2, *after* Orionis *transfer* 133 *from* No. 186 *to* No. 189.
199,	,,	2, *for* 23 Leporis, *read* 13 Leporis.
272,	,,	2, *after* Canis Minoris, *insert* 31.
322,	,,	4, *for* 8 7·1, *read* 8 8·4.
738,	,,	*Note* † *for* 41 23·2, *read* 48 49·2.
795,	,,	*col.* 6, *for* 19 4·1, *read* 99 4·1.
801,	,,	*cols.* 4, 6, 8, *for* 24 45·5, *read* 24·8; *for* 32 6 45, *read* 32 6·8; *and for* B.A.C. *read* (B.A.C.).

Lastly, at the end of the Catalogue add.

Omitted Stars.

No.			h m s	s	° ′ ″	″	
435 *bis*	Bootis	V. 98	14 7 24·0	+ 3·00	84 2 13	+ 17·1	Σ.P.M.
742 *bis*	79 Cygni	VI. 57	21 38 27·8	+ 2·47	52 15 56	− 16·3	B.A.C.
813	Cassiopeæ	V. 79	24 ±	..	unidentifiable	..	..

Collingwood, ***Feb.*** 22, 1868.

On the Planetary Nebula 45 H IV. *Geminorum.*
By H. C. Key, Esq.

During the last three years I have constantly observed this remarkable object whenever a favourable opportunity occurred, but until the last few months without any special result. My instrument during that period had been only sufficient to show the star as nebulous, an intervening darker space round the nucleus, and a faint luminous ring at some distance. Since that time my optical means have been considerably increased, and a careful scrutiny has brought to light an additional feature, which seems to have escaped the notice of former observers, and of sufficient interest to induce me to lay it before the Society.

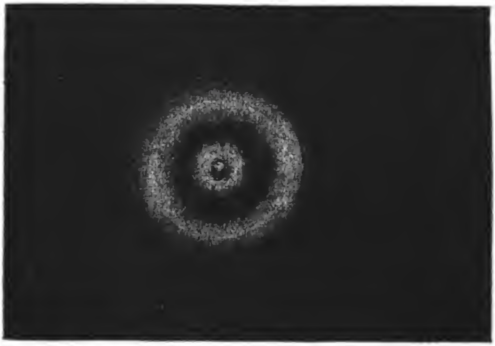
Smyth tells us (*Cycle*, vol. ii. p. 176) that in 1787 Sir William Herschel observed this object, and described it as "a star of the 9th magnitude, with a pretty bright nebulosity, equally dispersed all around;" and he calls it "a very remarkable phenomenon." And that Sir John Herschel describes it as "a star of the 8th magnitude, exactly in the centre of an exactly round bright hemisphere 25″ in diameter."

From the Earl of Rosse's account of this object in the *Philosophical Transactions*, 1850, of which Mr. Knott has kindly forwarded me an abstract and rough drawing, it appears that he saw it as a nebulous star with a black patch close to it on the preceding side, a less luminous space, somewhat unequal in breadth, surrounding the nucleus, and a luminous ring at some distance; this ring being of less breadth on the following side.

Mr. Lassell's drawing of this object in 1862 (*Mem. R. A. S.* vol. xxxvi.) represents a star in the centre of a planetary disk, surrounded by a non-luminous space; and, at some distance, by a luminous ring of considerable breadth. He also says, "I can see no trace of the dark patch in Lord Rosse's drawing near the bright centre."

The present appearance of this object, as seen in my instrument, is that of a bright, but somewhat nebulous star closely surrounded by a dark ring; this again by a luminous ring; then an interval much less luminous, and, finally, at some distance, an exterior luminous ring.

The accompanying drawing (which has been repeatedly verified and corrected), although an inadequate one, if held at such a distance from the eye that the interior bright ring is just seen distinctly detached from the central star, gives a tolerably fair representation of this remarkable object as it appears in my instrument.



45 H IV. Gem. 18-inch Reflector, power 510.

The whole is almost exactly symmetrical, although not quite so; the dark space between the two bright rings being darker on the north following side, and the preceding side of the whole object is rather fainter than the rest. Of the two luminous rings the interior is considerably the brightest. Like the annular nebula in *Lyra*, this object bears magnifying wonderfully well: with 150 little more is to be seen than a star in the centre of an extensive gauzelike, nebulous disk; with 300 I detected the interior ring; and 510 I found the most suitable power in every respect; with 666 I did not seem to gain any advantage, but rather the contrary. I may add that I have failed to see anything of the black patch in the Earl of Rosse's drawing, as well as the star shown by Mr. Lassell near the edge of the nebula.

On considering these several observations, which extend over a period of 81 years, from 1787 down to the present time, we can hardly fail to be struck by the progressive character of the results, which seems to be independent of the optical means employed. To both Sir William and Sir John Herschel there appeared merely a uniform nebulous planetary disk surrounding the central star, without any indication of a ring. To the Earl of Rosse, with his enormous optical power, there was visible only one exterior ring, and a small circular dark space near the central star, preceding it. To Mr. Lassell, with scarcely inferior power (comparatively), there was no appearance of an interior luminous ring. While, in my own instrument, which, although somewhat more powerful than the 20-foot reflectors (front view) of the Herschels, is of incomparably inferior power to the instruments of the Earl of Rosse and Mr. Lassell, the interior bright ring was visible at once during the first night's observation, and with a power of 510 is quite obvious.

Not to draw any very definite conclusions from these results, one fact, at all events, seems abundantly evident,—viz., that whereas at the date of the Herschels' observations there was no appearance whatever of a ring surrounding the central star, at the present time there are two.

The instrument with which my observations were made consists of a silvered glass speculum of 18 inches aperture and 10 feet focal length, of my own making, mounted as a Newtonian equatorially.

I estimated the extreme diameter of the whole object at 35″; and the diameter of the inner ring, taken at its brightest part, at 9″; while its inner diameter I judged to be about 5″.

Stretton Rectory, Hereford,
February 26, 1868.

Postscript, March 23.—Since writing the above I have seen a dark patch situated in the inner dark ring close to the central star. It is a very faint object in my instrument, but I can speak with certainty of its existence; the estimated angle of position is about 5°. I am not aware of the position of the dark patch seen by the Earl of Rosse.

Note on the Occultation of α Tauri on May 22, 1868.

(*Communicated by R. S. Newall, Esq.*)

It may perhaps be desirable to call the attention of observers to the occultation of *α Tauri* on May 22, 1868, because it is not mentioned in the *Nautical Almanack* and other ephemerides on account of its occurring near the time of New Moon. As the star will be about 8° distant from the Sun, there seems little reason to doubt that, in a clear sky, and with a good Equatoreal, the occultation may be observed very well, provided the necessary precautions are not neglected. At any rate, the observation will be worth trying, be it merely as a matter of curiosity, since a similar favourable opportunity of observing an occultation of *α Tauri* so near the Sun will not offer itself again before the year 1885 or 1886.

The elements for computing the occultation beforehand, according to Bessel's formulæ (which may be found in the *Berliner Jahrbuch* and in the *Connaissance des Temps*), are these:—

For Greenwich, Paris, and neighbourhood.	For Washington and neighbourhood.
T = May 22 $6^h\ 50^m{\cdot}0$ Greenwich M.T.	T = $5^h\ 50^m{\cdot}0$ Greenwich M.T.
$h = 96^\circ\ 5'{\cdot}2$	$h = 81^\circ\ 2'{\cdot}7$
$p = +\ 0{\cdot}6394$	$p = +\ 0{\cdot}6464$
$q = +\ 0{\cdot}6320$	$q = +\ 0{\cdot}5316$

$$p' = + 0{\cdot}5930$$
$$q' = + 0{\cdot}1003$$

The following list contains the local mean times of disappearance and reappearance for a few observations and also the corresponding angles of position Q of the star at the apparent centre of the Moon.

	Disappearance, Local M.T.		Q	Reappearance, Local M.T.		Q
	h	m		h	m	
Berlin	7	20·9	41·3	7	57·4	308·4
Bonn	6	56·0	51·8	7	39·3	298·3
Cambridge, England	6	26·1	53·0	7	11·5	296·6
Cambridge, Mass.	0	37·5	100·4	1	50·6	234·1
Greenwich	6	26·1	55·1	7	12·6	294·6
Liverpool	6	12·3	51·8	6	57·9	297·4
Oxford	6	20·7	55·3	7	7·5	294·4
Paris	6	37·4	60·9	7	25·6	289·4
Washington	0	3·1	108·7	1	12·1	223·5

It need scarcely be mentioned that, in order not to miss the reappearance, the place of emergence will have to be determined with some care. Bessel's expedient, of placing a wire in the direction Q ± 90°, and finding the part of the Moon's limb at which it is a tangent, will perhaps give little trouble at the European observatories, as the reappearance takes place near the middle of the illuminated crescent, where its breadth will be nearly 10″. At the American observatories, where the star reappears near the thin horns of the crescent, the difficulty will be somewhat greater. The direction and distance of the Sun's centre with respect to the star are:

G.M.T.	Angle of Position.	Distance.
6h	302° 52′·3	8° 10′·9
8	303 15·1	8 7·3

Observations of Planets (94), (95), (96), *and* (97). By Dr. R. Luther.

(94), discovered by Mr. Watson at Ann Arbor. 11.12 magnitude.

	Bilk M.T.	R.A.	Decl.	
	h m s	h m s	° ′ ″	
1867, Oct. 25	8 56 16·4	0 20 39·70	+4 35 46·8	13 comp.
26	8 30 49·8	0 20 3·49	+4 34 9·3	10 „
28	9 9 24·5	0 18 51·67	+4 30 55·9	9 „

(95), discovered by myself at Bilk, Düsseldorf. 10.11 magnitude.

	Bilk M.T.	R.A.	Decl.	
	h m s	h m s	° ′ ″	
1867, Nov. 23	9 48 15·7	4 1 32·00	+21 30 17·1	11 comp.
23	11 11 1·6	4 1 28·81	+21 29 53·0	10 ,,
29	8 59 20·0	3 56 24·29	+20 44 47·3	2 ,,
Dec. 3	10 28 32·7	3 53 4·23	+20 13 59·4	12 ,,

The name *Arethusa* was kindly given by Professor Galle and Dr. Günther at Breslau.

(96), discovered by M. Coggia at Longchamp, Marseilles.
11 magnitude.

	Bilk M.T.	R.A.	Decl.	
	h m s	h m s	° ′ ″	
1868, Feb. 28	9 42 35·4	9 23 40·85	+13 29 48·2	8 comp.

Hourly Motion −2ˢ in R.A., −5″ in Decl.

(97), discovered by M. Tempel at Marseilles. 10.11 magnitude.

	Bilk M.T.	A.R.	Decl.	
	h m s	h m s	° ′ ″	
1868, Feb. 28	12 37 20·3	11 44 24·26	+4 41 52·5	8 comp.

Hourly Motion −2ˢ in R.A. +25″ in Decl.

(97) is surely different from (91) *Ægina.*

In the month of January 1868 I have found the following corrections of the Berlin Ephemerides:—

	R.A.	Decl.
	s	′
Parthenope	+3·8	+0·1
Hebe	−0·1	+0·2
Julia	−5·1	+0·2
Ausonia	+0·2	−0·0

Bilk, Düsseldorf, 1868, *March* 4.

Ephemeris of Brorsen's Comet. By Dr. C. Bruhns, Director of the Observatory of Leipzig.

I found with the perturbations of *Jupiter* the following systems of elements from the appearances of 1846 and 1857.

	1846.		1857.		1868.	
T	Feb. 25·406 Berl. T.		Mar. 29·2829 Berl. T.		Apr. 18·4835 Berl. T.	
	° ′ ″		° ′ ″		° ′ ″	
π	126 28 17·1	Mean Equin. 1846·0.	115 45 54·3	Mean Equin. 1857·0.	116 2 3·1	Mean Equin. 1870·0.
☊	102 41 41·3		101 47 27·9		101 14 5·5	
i	30 55 16·9		29 48 45·2		29 22 38·5	
φ	52 28 23·7		53 17 28·2		53 54 35·6	
M	637″·151		640″·732		647″·0618	

With the latter Elements we obtain for the present appearance the following Ephemeris :—

1868. 0h Berlin T.	α App. h m s	δ App. ° ′	Log. Δ	Log. γ
Mar. 10	1 7 53	− 8 8·5	0·23966	9·97841
11	10 58	7 34·0		
12	14 5	6 58·8		
13	17 14	6 23·0		
14	20 24	5 46·6	0·22708	9·95383
15	23 37	5 9·6		
16	26 52	4 31·9		
17	30 9	3 53·6		
18	33 28	3 14·6	0·21382	9·92837
19	36 50	2 34·9		
20	40 14	1 54·6		
21	43 40	1 13·6		
22	47 9	− 0 31·9	0·19985	9·90233
23	50 40	+ 0 10·5		
24	54 13	0 53·7		
25	57 49	1 37·7		
26	2 1 27	2 22·3	0·18515	9·87614
27	5 8	3 7·7		
28	8 52	3 53·8		
29	12 38	4 40·7		
30	16 27	5 28·4	0·16967	9·85050
31	20 19	6 16·9		
Apr. 1	24 13	7 6·0		
2	28 10	7 56·0		
3	32 9	8 46·7	0·15340	9·82648
4	36 12	9 38·2		
5	40 18	10 30·4		
6	44 27	11 23·3		
7	48 39	12 16·9	0·13635	9·80544
8	52 54	13 11·2		
9	57 12	14 6·2		
10	3 1 33	15 1·9		
11	5 58	15 58·2	0·11853	9·78899
12	10 26	16 55·0		
13	14 58	17 52·4		
14	19 33	18 50·3		
15	24 11	19 48·6	0·10006	9·77875
16	28 53	20 47·3		
17	33 41	21 46·5		
18	38 32	22 46·0		
19	43 27	+ 23 45·6	0·08113	9·77587

1868. 0^h Berlin T.	α App.	δ App.	Log. Δ	Log. γ
	h m s	° ′		
Apr. 20	3 48 27	+ 24 45·5		
21	53 32	24 45·5		
22	58 42	26 45·6		
23	4 3 58	27 45·6	0·06207	9·78072
24	9 20	28 45·6		
25	14 50	29 45·4		
26	20 26	30 44·9		
27	26 7	31 44·0	0·04336	9·79271
28	31 56	32 43·0		
29	37 54	33 41·3		
30	44 0	34 39·1		
May 1	50 16	35 36·2	0·02546	9·81050
2	56 41	36 32·5		
3	5 3 16	37 27·8		
4	10 2	38 22·1		
5	16 59	39 15·4	0·00895	9·83246
6	24 7	40 7·4		
7	31 27	40 58·1		
8	39 0	41 47·3		
9	46 46	42 34·8	9·99440	9·85701
10	54 45	43 20·5		
11	6 2 57	44 4·3		
12	11 23	44 46·0		
13	20 1	45 25·4	9·98229	9·88287
14	28 53	46 2·4		
15	37 59	46 36·9		
16	47 16	47 8·8		
17	56 45	47 37·8	9·97313	9·90909
18	7 6 26	48 3·8		
19	16 16	48 26·6		
20	26 14	48 46·3		
21	36 19	49 2·8	9·96724	9·93502
22	46 30	49 15·8		
23	56 46	49 25·3		
24	8 7 4	49 31·4		
25	17 22	49 34·1	9·96488	9·96027
26	27 38	49 33·4		
27	37 52	49 29·3		
28	48 2	49 21·7		
29	58 6	+ 49 10·7	9·96615	9·98460

14 *March*, 1868.

*Description of a Zenith Telesoope.** By J. Simms, Esq.

I have been requested by several members of the Society to describe this Zenith Telescope, with the view of bringing forward a method of determining the latitude which has been for several years generally adopted by the United States Coast Survey, and which not only has the advantage of being simple, but also when the places of the stars made use of have been well ascertained, is extremely accurate.

The instrument is supported upon a strong tripod having feet screws for levelling; to this tripod is fixed the azimuth circle and also the fixed vertical axis. A hollow axis which serves to support the upper part of the instrument, moves upon the fixed axis. The upper part consists of a telescope, fixed to the end of a horizontal moveable axis, so that, in fact, the movements are those of an altazimuth. An extremely sensitive level is fixed to the telescope which also carries a micrometer with a screw of long range. There is a peculiarity in this instrument in the manner of bringing the weight of the upper part over the centre of the upright pillar, which deserves notice. In order to accomplish this, and at the same time to avoid the flexure which would be caused by the overhanging position of the telescope, a steel lever having its fulcrum over the centre of the instrument is, by a bend, passed round to the front of the telescope, where it supports a small pivot which is really a continuation of the horizontal axis, the other end of the lever carries a counterpoise.

The Zenith Telescope in its present form was arranged by Würdermann of Washington, U.S.

In Pearson's *Astronomy* may be seen represented two varieties of Zenith Telescope, one of which has the level and micrometer of Würdermann's instrument, whilst the other possesses the horizontal axis, it wonld thus appear that the modern form is a combination of two previously existing models.

The method of observation is known as Talcott's, it is described in the U. S. Coast Survey Report for 1857.

Two stars are selected, one of which passes the meridian to the north, and the other at nearly the same distance to the south of the zenith. The telescope is brought into the plane of the meridian and set for the star which first passes the meridian; when visible it is bisected by the micrometer wire, the tangent screw of the instrument being used. The telescope is then turned 180° in azimuth, and when the second star makes its appearance, should there be any difference in the zenith distances, this difference is measured by the micrometer screw.

It is evident that, having the sum of the zenith distances as given by the Catalogue, and having obtained the difference by means of the instrument, the latitude may be readily deduced therefrom.

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* Exhibited at the Meeting. Ed.

Should the position of the level vary between the two observations, a correction will have to be applied; refraction may, in general, be neglected, as the difference in the refraction of the two stars (in most cases a very small quantity) is that which alone has to be regarded.

From a paper by the late Mr. Pond, Astronomer Royal, read before the Royal Society, March 13, 1834, entitled "Some Suggestions relative to the best method of employing the New Zenith Telescope lately erected at the Royal Observatory," it would appear that he suggested and made use of this mode of observing: this paper appears to have been generally lost sight of.

The Great Nebula in Orion. By Father A. Secchi.

I take the liberty of presenting to the Royal Astronomical Society a drawing of the great Nebula of *Orion*, which was commenced several years ago, and finished last year by combined observations made by myself and Padre Ferrari, my assistant. Last autumn some copies of it were distributed to friends, but not as definite specimens. Lately I have re-examined this object and found the figuring correct, as seen on dark nights in our 9-inch refractor. But upon observing it in moonlight, I was surprised at the amount of details which then came out. I resolved, therefore, to take advantage of this circumstance, and to introduce these details into the drawing, making the observations in different phases of the Moon to obtain a more distinct graduation of light.

The present drawing embraces these results, which will, I hope, prove interesting. It may appear extraordinary that we should see such an object better in moonlight, but this is not very surprising, since it is only a consequence of that optical principle, that the difference of two lights is more easily appreciated when they are weak than when they are both very strong. This, therefore, is a case like that of the spots on *Venus*, which are better seen in daylight than at night, and of the bands of *Jupiter*, which are better seen in twilight than in complete darkness. I, consequently, hope that this drawing will not be useless, even after the great work of Lord Rosse; and it will at least show how much may be seen with an instrument of comparatively limited power, and that some information may thus be obtained respecting the influence caused by the aperture, and the amount of light of the instrument.

As I have not yet received the *Philosophical Transactions* I have not been able to compare my results with those of Lord Rosse. I saw his lordship's drawing at Sir John Herschel's last October, and I then found that the principal masses in my drawing agreed with it; I therefore hope that these minor details may in like manner agree.

As regards the spectrum of the Nebula, I have nothing to add, except that I have made an experiment which may explain why we see only one of the three hydrogen lines in the Nebula. Having obtained by a Geissler tube a good spectrum of pure hydrogen with the three characteristic lines, I found that, by diminishing the light by reflexion on a glass plate, the two lateral ones disappeared, the middle line only remaining, which is that visible in the Nebula. The simple diminution of the light may therefore account for the other two lines of this gas not being visible. I think, therefore, that it would be of great interest to have this Nebula observed in Southern regions with a larger instrument in order to ascertain, if possible, whether the other two lines can thus be rendered visible.

Extract of a letter from Father Secchi to Admiral Manners:—

"*Rome, March* 27, 1868.

"I am busy about the spectrum analysis of stars, and you will see in the *Comptes Rendus* a very advantageous method of determining the motion of the stars in space by the spectrometer. I, however, require a larger instrument, because a 9-inch object-glass is rather too small for this purpose. I have greatly improved the direct view spectroscope, so that it has become a very suitable instrument. I have introduced an eye-piece, made completely with cylindrical lenses, which is exceedingly powerful, and leaves a great deal of light. I have examined almost the whole of the Red Stars in the Catalogue of M. Schellerup, and have arrived at some very interesting conclusions. All these red stars have spectra, either furnished with bands and striæ like *α Orionis*, or like the star *Lalande* 12561, figured in my second map of the Memoir, which I have sent to the Society. As soon as the full review is finished, I will send the complete Catalogue to the Society, with figures and description.

"I have since studied the spectrum of *α Orionis* more accurately, and it seems to me that the hydrogen lines exist even in it. I have got a very good spectroscope, with a double prism, by Hoffman, and some wonderful prisms by M. Merz: with one of these I can see as many lines in the solar spectrum, as Bunsen saw with his four prisms.

"I have made a *resumé* of all the measures of double stars taken since my last publication in 1859, and in number they amount to 158 objects, the greater part of them periodical, and many of them have changed their position since my last measures, and those of Struve."

The Rev. W. R. Dawes, died February 15, at Haddenham, aged 68 years.

CONTENTS.

Page
Fellow elected 129
On the Comets 1857, III. and V., and 1867, III. by M. Hoek .. .. ib.
On the Phenomena which a very extended Swarm of Meteors coming from Space presents after its entry into the Solar System, by M. Hoek 131
Additional Identifications of Double Stars in the Synoptic Catalogues of Sir William Herschel's Micrometrical Measurements, &c., with a List of Errata, by Sir J. F. W. Herschel 151
On the Planetary Nebula 45 H IV. *Geminorum*, by Mr. Key 154
Note on the Occultation of *α Tauri* on May 22, 1868 156
Observations of Planets (94), (95), (96), (97), by Dr. Luther 157
Ephemeris of Brorsen's Comet, by Dr. Bruhns 158
Description of a Zenith Telescope, by Mr. Simms 161
The Great Nebula in *Orion*, by Father Secchi 162
Death of the Rev. W. R. Dawes 163

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MONTHLY NOTICES

OF THE

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University of MICHIGAN LIBRARY

Admiral **Manners**, President, in the Chair.

W. Lloyd Wise, Esq., Greenhythe,
was balloted for and duly elected a Fellow of the Society.

On the Rejection of Discordant Observations.
By E. J. Stone, Esq.

In the discussion of the results of observation there is nothing more unsatisfactory than the necessity, which occasionally arises, for the rejection of certain results because of their discordance with the general average given by numerous observations. These discordant results will in many cases be found to be deduced from observations made by observers of great experience and skill, and apparently under most favourable circumstances. In such cases our minds are almost irresistibly led to assume that causes of error must have been in action other than those causes which lead to the ordinary graduated errors. It is clear, however, that such assumption of irregular causes must not be made without great caution and reserve. So far as I know only two criteria for the rejection of apparently anomalous results have been published. In No. 45 of Dr. Gould's *Astronomical Journal*, Professor Peirce has published an investigation leading to formulæ of some complexity for the rejection of such observations. The employment of these formulæ is rather troublesome, and grave doubts have been expressed with respect to the accuracy of the heory upon which they are based. See Airy, No. 90 of Gould's *Astronomical Journal.*

In Chauvenet's most valuable *Treatise on Astronomy*, vol. ii. page 565, will be found a simple criterion for the rejection of one observation. This criterion is introduced ostensibly for the purpose of clearing up certain difficulties in the understanding of Peirce's criterion. Chauvenet's criterion may be stated as follows:—

If $\theta(x)$ denote the probable number of errors equal to or greater than x, when the whole number of observations is denoted by unity, then the number of errors equal to or greater than x, which may fairly be expected in n observations is $n\,\theta(x)$. If therefore we find x such that $n\,\theta(x) = \frac{1}{2}$, any error greater than x will have a greater probability against it than for it, and may, therefore, be rejected.

This criterion appears to me to be based on an erroneous principle. In $2\,n$ such observations we ought reasonably to expect one error equal to or larger than x. In n observations therefore we ought not to be surprised at the appearance of such an error, and certainly its appearance would be no fair ground for an assumption of some disturbing cause of error.

I have been led, on consideration of this subject, to a formula which embodies, in my opinion, the true grounds upon which my judgment rests when compelled to reject discordant observations.

If a is the ordinary probability parameter of a class of observations, we have for the probability of an error equal to or greater than p,

$$\frac{2}{\sqrt{\pi}}\int_{p}^{\infty} \epsilon^{-\frac{x^2}{a^2}}\,\frac{dx}{a},$$

or if $y = \frac{x}{a}$, the probability

$$= \frac{2}{\sqrt{\pi}}\int_{\frac{p}{a}}^{\infty} \epsilon^{-y^2}\,dy.$$

As a matter of fact, we know that *mistakes* do occur in the making and registering of observations. To confine our attention, for example, to observations in zenith distance, the observer may omit to clamp the circle and the instrument may be moved between the bisection of a star and the reading of the microscopes. He may clamp the circle inadvertently, after having made his bisection. He may bring the declination wire nearly to bisect the star, with the intention of completing the bisection at the centre of the field, and then forget to make the bisection. He may accidentally touch the declination screw, or micrometer heads, after the bisections have been made and before the readings have been registered. He may read off wrongly the heads of his micrometers or transpose his readings in entering them in the observing book; or he may enter erroneously the readings of the barometers or thermometers required for the calculation of the refraction corrections. These, and possibly other, errors we know that an experienced and careful observer may make in entire ignorance of there being anything wrong in his work. We have here a series of causes of errors entirely distinct from those which lead to the ordinary graduated errors.

For a given class of observations and for a given observer there must exist a number n, which expresses the average number of observations which that person makes with one mistake. n may be defined as the modulus of carelessness.

If, therefore, we find that value of p, which makes

$$\frac{2}{\sqrt{\pi}}\int_{\frac{p}{a}}^{\infty} \epsilon^{-y^2}\,dy = \frac{1}{n},$$

all larger values of p are, with greater probability, to be attributed to mistakes than to the ordinary run of graduated errors. Larger values of error than p must therefore be rejected. If e denote the probable error of an observation, we have

$$e = 0{\cdot}4769 \times a,$$

our equation for the determination of p becomes therefore

$$\frac{2}{\sqrt{\pi}}\int_{p\,\frac{0\cdot4769}{e}}^{\infty} \epsilon^{-y^2}\,dy = \frac{1}{n}.$$

From which, so long as n remains constant, we see that the limit of rejection varies directly as the ordinary probable error.

The following table gives the limits of rejection, with a probable error 0″·477, for different values of the modulus of carelessness n. It may be mentioned that the assumed probable error is about that of a Greenwich observation of *Polaris* in N.P.D.

Value of n.	Limit of Rejection. ″
5	0·95
10	1·2
20	1·4
40	1·6
80	1·8
100	1·9
1000	2·3
10000	2·7

If this theory is correct, the meaning of these numbers is as follows. Suppose we are satisfied that on an average our observer makes one mistake in a thousand observations. I mean such a mistake as cannot be detected and corrected with perfect, or almost perfect certainty. Then, with a probable error of 0″·477, all discordances, from the mean of a great number of observations, greater than 2″·35, should be at once rejected.

Discordances so large as 2″·75 should not be retained unless we are prepared to believe that our observer only makes one mistake in making and registering 10,000 observations. Discordances so small as 0″·95 ought not to be rejected unless we are prepared to believe that, on an average, our observer makes one mistake in five observations. It is perhaps impossible to determine the absolute value of n for any class of observations, but an inspection of the tables shows that the limit of rejection varies very slowly for any values of n which would be admissible in the case of observations made by careful and experienced persons. A rough value of n is quite sufficient for practical purposes, but when once a value of n is admitted, all rejections are determinate. If this theory is correct our rejection cannot be made, except upon a direct admission of carelessness.

The following table would give, according to this theory, the limits of rejection for different probable errors with an assumed value of $n = 500$:—

Probable Error.	Limit of Rejection.
″	″
0·12	0·55
0·48	2·2
0·95	4·4
1·91	8·8
3·82	17·6

or very roughly about five times the probable error.

Note on the Employment of the Table given in the Nautical Almanac, "showing the Correction required on account of Second Differences in finding the Greenwich Time corresponding to a reduced Lunar Distance." By Capt. Shadwell, R.N.

Finding the time corresponding to a reduced lunar distance is effected by the inverse application of the general formula of interpolation

$$F_{(n)} = F + n\,a' + \frac{n\,.\,\overline{n-1}}{1\,.\,2}\,b' + \&c.$$

whence, transposing and disregarding the second differences, we have as a first approximation

$$n_1 = \frac{F_{(n)} - F}{a'}, \qquad (1)$$

and again, as a more correct result, taking account of the second differences,

$$n_2 = \frac{F_{(n)} - F}{\left(a' + \frac{n_1 - 1}{2} b'\right)}. \qquad (2)$$

The lunar distances being registered in the ephemeris for every three hours, $n_1 = \frac{t^h}{3^h}$, $n_2 = \frac{t'^h}{3^h}$; also $F_{(n)} - F = \Delta'$, the partial difference between the given lunar distance and the one which next precedes it in the Table; hence we have

$$t = 3^h \times \frac{\Delta'}{a'},$$

and in logarithms

$$\log t = \log \Delta' + \text{P} \log a',$$

and similarly

$$\log t' = \log \Delta' + \text{P} \log \left(a' - \frac{3^h - t}{3^h} \frac{1}{2} b'\right).$$

The proportional logarithm of a' (the difference between the consecutive values of the distance) is given in the ephemeris; denoting this by Q, and the difference between it and the one which next follows it by Δ Q, we have

$$\left.\begin{aligned} \log t &= \log \Delta' + Q, \\ \log t' &= \log \Delta' + \left\{ Q - \frac{3^h - t}{3^h \frac{1}{2}} \Delta Q \right\}, \end{aligned}\right\} \qquad (3)$$

in which we should employ an interpolated value of the proportional logarithm, and assume that the variation of Q is proportional to the corresponding change in a', which is very nearly true.

Or again, wholly employing proportional logarithms,

$$\left.\begin{aligned} \text{P} \log t &= \text{P} \log \Delta' - Q, \\ \text{P} \log t' &= \text{P} \log \Delta' - \left\{ Q - \frac{3^h - t}{3^h} \frac{1}{2} \Delta Q \right\}, \end{aligned}\right\} \qquad (4)$$

by which first t, and then t', might be obtained.

It is usual however in practice only to find the approximate interval t, from the above equation, and then to determine the correction $t'-t$ by aid of a subsidiary table, which is obtained in the following manner.

Subtracting the first equation in (3) from the second, we have

$$\log t' - \log t \text{ or } \log \frac{t'}{t} = -\frac{3^{\mathrm{h}} - t}{3^{\mathrm{h}}}\,\frac{1}{2}\,\Delta \mathrm{Q}.$$

But by the properties of logarithms,

$$\log \frac{t'}{t} = \mathrm{M}\,\frac{t' - t}{t} \text{ very nearly,}$$

$\frac{t'-t}{t}$ being necessarily a very small fraction; M being the Modulus of our system of common logarithms 0·434294.

Hence by substitution in the above

$$\mathrm{M}\,\frac{t'-t}{t} = -\frac{3^{\mathrm{h}} - t}{3^{\mathrm{h}}}\,\frac{1}{2}\,\Delta \mathrm{Q},$$

whence

$$t' - t = -\frac{t\,.\,(3^{\mathrm{h}} - t)}{2 \times 3^{\mathrm{h}} \times \mathrm{M}}\,\Delta \mathrm{Q},$$

which gives the correction in units of an hour, or expressing it in seconds,

$$(t'-t)^{\mathrm{s}} = -\frac{t^{\mathrm{m}}\,(180 - t^{\mathrm{m}})}{2{\cdot}605764}\,\Delta \mathrm{Q}$$

$$= -\,t^{\mathrm{m}}\,(180 - t^{\mathrm{m}})\;[\bar{1}{\cdot}584064]\;\Delta \mathrm{Q} \qquad (5)$$

From this formula (5) the table given in the *Nautical Almanac* and other works* is computed; the arguments being the approximate interval t expressed in minutes, and the *significant* figures of the difference of the proportional logarithms, Δ Q.

It is customary, and in accordance with the precepts given in the *Nautical Almanac* (Annual Explanation) and other works, to use the difference between the two proportional logarithms standing opposite to the two distances, which include the given distance, as Δ Q; this is equivalent to the employment of the second difference, b', in equation (2), and only takes into account the second difference which follows the function F from which we set out, taking no account of the second difference obtained by considering the values of the functions which precede it; the result is that the time obtained is *over-corrected* when the proportional logarithms are *increasing*, and *under-corrected* when they are *decreasing*, the second differences having in fact been assumed as constant when they may really not be so.

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* Norie, Table LIV.; Raper, Table, 57, &c.

When there is great irregularity of variation in the successive values of the lunar distances, this circumstance may produce a very sensible error in the resulting time.

This defect can however be remedied in a very simple manner by employing the formula attributed to Bessel, and using the *mean* second difference $b_0 = \frac{b' + b}{2}$ instead of b' as before, that is to say, by deducing the correction from the formula

$$F_{(n)} = F + n\, a' + \frac{n \,.\, n - 1}{2}\, b_0.$$

This would be effected in using the table by employing as the argument "difference of proportional logarithms," *not* the difference between the proportional logarithms standing opposite the distances in the ephemeris which include the given distance, but the *mean* of this difference and the one which precedes it.

Thus, suppose the given distance for which the time is required fell between 9^h and midnight, we should use the *mean* difference between the proportional logarithms standing against 6^h and 9^h, and 9^h and midnight, and so on, in like cases.

Example 1. Required the Greenwich mean time corresponding to the Moon's distance from Fomalhaut, $31^\circ\ 42'\ 57''$, on Nov. 6, 1864. (From the *Nautical Almanac*, 1864, Explanation, p. 521.)

In this case the given distance falls between the distances in the *Almanac* at IX^h. and midnight, the approximate interval is found to be $1^h\ 28^m\ 52^s$.

The "difference of prop. logs" at IX^h. and midnight is 235, from which and the "approximate interval," $1^h\ 30^m$, we get as the correction 89^s to be subtracted, and finally the G.M.T. becomes $10^h\ 27^m\ 23^s$.

A rigorous solution of the example by the formula of interpolation, using the *mean* second difference b_0, gives the G.M.T. $10^h\ 27^m\ 31^s{\cdot}5$, which differs from the *Nautical Almanac* result by $8^s{\cdot}5$, or a little more than two miles of longitude.

Again, the "diff. prop. log." at VI^h. and IX^h. is 242, and between IX^h. and midnight 285, the *mean* of which is 263. Using this as the argument of the table, we get the correction 81^s, which gives the corresponding G.M.T. $10^h\ 27^m\ 31^s$, agreeing with the above result by a rigorous computation.

Example 2. Required the Greenwich mean time corresponding to the Moon's distance from *Pollux* $18^\circ\ 5'\ 2''$ on February 14, 1867. (From the Explanation, *Nautical Almanac*, 1867, p. 528.)

Here the approximate interval comes out $1^h\ 30^m\ 10^s$, the distance lying between XV^h. and $XVIII^h$., and the "difference of the prop. logs" at those times is 247, from which and the "approximate interval" $1^h\ 30^m$, the table gives the correction 78^s to be subtracted, whence finally the G.M.T. becomes $16^h\ 28^m\ 52^s$.

A rigorous solution by the formula of interpolation gives the

G.M.T. $16^{h}\ 29^{m}\ 4^{s}\cdot5$, which differs from the *Nautical Almanac* result by $12^{s}\cdot5$, which is equivalent to three miles of longitude.

Again, the "diff. prop. logs" at XV^{h}. and XVIII^{h}. is 247, while between midnight and XV^{h}. it is 186, hence the *mean* difference is 216. Using this as the argument of the table we get the correction 68^{s}, which applied to the approximate G.M.T. gives finally $16^{h}\ 29^{m}\ 2^{s}$ as the corrected time, which result agrees much more nearly with that obtained by a rigorous application of the formula before mentioned.

It may possibly be objected that these are extreme cases, and that the cases involved will not generally be so large; this may no doubt be true, but as the mode of rightly employing the table only involves a very simple change of procedure, there seems to be no good reason why it should not be adopted.

Haslar, March 20, 1868.

Occultations of Stars by the Moon, and Phenomena of Jupiter's Satellites, observed at the Royal Observatory, Greenwich, from January to December, 1867.

Occultations of Stars by the Moon.

Day of Obs. 1867.		Phenomena.	Moon's Limb.	Mean Solar Time. h m s	Observer.
May 6	(*a*)	117 Tauri disapp.	Dark	8 3 56·5	C.
		117 Tauri, reapp.	Bright	8 40 52·4	C.
June 14		49 Libræ, disapp.	Dark	12 31 15·7	J. C.
Nov. 6	(*b*)	Aquarii, disapp.	Dark	10 28 17·7	J. C.
8		10 Ceti, disapp.	Dark	7 7 0·5	E.

(*a*) Extremely faint: the observation doubtful perhaps to a second or two.

(*b*) Cloudy. The time noted by the observer has been increased by one minute.

Phenomena of Jupiter's Satellites.

Day of Obs. 1867.	Sat.	Phenomena.	Mean Solar Time. h m s	Observer.
June 14	III.	Occult. reapp. bisection	14 27 4·4	J. C.
28	III.	Eclipse, disappearance	13 32 46·5	D.
July 9	III.	(*a*) Transit, ingress, bisec.	12 0 11·7	K.
10	IV.	Eclipse, reappearance	13 43 28·6	E.
Aug. 10	III.	Eclipse, disappearance	13 37 34·5	D.
Sept. 5	I.	Occult. disapp. first cont.	10 41 37·2	J. C.
	I.	,, ,, bisection	10 43 21·9	J. C.
	I.	,, ,, last cont.	10 45 36·6	J. C.
5	I.	Eclipse, reappearance	13 17 26·8	J. C.

Day of Obs. 1867.	Sat.	Phenomena.	Mean Solar Time. h	m	s	Observer.
Sept. 6	I.	Transit, ingress, bisec.	7	58	44·3	K.
	I.	,, ,, last cont.	8	1	3·9	K.
15	III.	(*b*) Occult. disapp. first cont.	7	27	1·2	J. C.
	III.	,, ,, bisection	7	30	30·6	J. C.
	III.	,, ,, last cont.	7	34	0·0	J. C.
	II.	Eclipse, reappearance	8	58	44·2	J. C.
	IV.	Occult. reapp. bisection	9	31	10·9	J. C.
	IV.	,, ,, last cont.	9	35	10·3	J. C.
	IV.	Eclipse, disappearance	10	0	11·2	J. C.
	IV.	(*c*) Eclipse, reappearance	14	23	53·2	J. C.
20	I.	Transit, ingress, first cont.	11	23	2·0	H. C.
	I.	,, ,, bisection	11	25	3·7	H. C.
	I.	,, ,, last cont.	11	27	41·3	H. C.
21	I.	Occult. disapp. bisection	8	39	38·1	E.
22	III.	Occult. disapp. first cont.	10	47	47·8	L.
	III.	,, ,, bisection	10	50	17·4	L.
	III.	,, ,, last cont.	10	52	17·0	L.
	II.	Eclipse, reappearance	11	34	49·6	L.
Oct. 1	II.	Transit, egress, bisection	7	26	49·9	P.
	II.	,, ,, last cont.	7	29	4·6	P.
10	III.	Transit, ingress, first cont.	7	45	33·0	K.
	III.	,, ,, bisection	7	49	7·4	K.
	III.	,, ,, last cont.	7	52	2·0	K.
	IV.	Transit, egress, bisection	10	4	54·8	K.
	IV.	,, ,, last cont.	10	10	3·9	K.
	III.	Transit, egress, bisection	11	26	36·4	K.
	III.	,, ,, last cont.	11	29	40·9	K.
17	II.	(*d*) Eclipse, reappearance	8	39	51·9	H. C.
28	III.	Occult. reapp. bisection	8	21	31·7	J. C.
	III.	,, ,, last cont.	8	23	31·4	J. C.
	III.	Eclipse, disappearance	9	55	56·0	J. C.
Nov. 2	II.	(*e*) Transit, egress, bisection	6	25	41·8	J. C.
	II.	,, ,, last cont.	6	28	41·3	J. C.
6	I.	Occult. disapp. bisection	8	32	14·0	J. C.
	I. (*f*)	,, ,, last cont.	8	35	13·6	J. C.
7	I.	Transit, egress, last cont.	8	1	18·8	C.
8	I.	Eclipse, reappearance	6	38	28·4	E.
11	II.	Eclipse, reappearance	5	48	44·8	C.
23	I.	Transit, egress, first cont.	6	18	48·6	C.
	I.	,, ,, last cont.	6	20	18·3	C.
Dec. 7	I.	(*g*) Transit, ingress, first cont.	7	56	3·2	C.

(*a*) The image blurred; the observation uncertain. (*b*) The image of the lanet very tremulous and diffused. (*c*) The image very bad. A little uncertain in consequence of the satellite reappearing close to the third satellite. (*d*) Very uncertain: appeared very near the third satellite. (*e*) The satellite faint: the planet badly defined. (*f*) The image of the planet very ill defined and tremulous. (*g*) The image of the planet very bad.

The initials D., E., C., L., J.C., K., and H.C., are those of Mr. Dunkin, Mr. Ellis, Mr. Criswick, Mr. Lynn, Mr. Carpenter, Mr. Kerschner, and Mr. H. Carpenter.

A Synoptical Catalogue of known and suspected Binary Stars. By G. F. Chambers, F.R.A.S.

About a year and a half ago, an able working astronomer whose name is by no means so well known to the Society as it should be, Mr. A. Brothers, F.R.A.S., of Manchester, presented to the Manchester Literary and Philosophical Society a very carefully prepared catalogue of known and suspected binary stars. Extending as it did, with the introduction, over twenty-seven closely-printed pages, it will readily be inferred that it was of a somewhat elaborate character; and such, indeed, was the case, for of some of the stars as many as twenty sets of measures by all the leading observers were given.

An abstract of this catalogue, kindly prepared for me at very short notice, was afterwards published in my *Descriptive Astronomy*, but as in the said abstract the places were not brought up to any uniform epoch, and as there were other defects in it which it is not worth while to particularise, I decided to take an early opportunity of computing all the places for the one epoch of 1870, and of re-writing the catalogue generally, with such textual revision as seemed necessary to bring it down to the present state of our knowledge. With this end in view, I have carefully collated all recent publications, including especially the valuable memoir of Mr. Dawes, just published,—his last legacy to us.

It does not occur to me that it is necessary to say much else by way of introduction. All the data have been selected from the latest and most trustworthy sources, and no pains have been spared to make the catalogue all that it should be.

The signs + and − in the last two columns indicate, it need hardly be said, that the position angle or the distance is increasing or diminishing as the case may be. A note of interrogation (?) denotes probability without certainty, but ± ? means that it is wholly impossible, owing to the discordances in the measures, to pronounce an opinion one way or the other.

A star (*) is prefixed to various objects of which I have been unable to discover any recent measures. It may therefore be taken that new measures of these are much wanted.

Part I. Known Binary Stars.

No.	Name of Star.	Struve's No.	R.A. 1870.	Decl. 1870.	Epoch 1880 +	Mag.	Position.	Distance.
			h m s	° ′			°	″
1	316 B Cephei	2	0 2 11	+78 56·2	65·7	5½, 6	295·5−	[0·38−]
2	318 B Cephei	13	0 8 53	+76 10·3	63·0	6, 6½	103·5−	0·50 −
3	η Cassiopeæ	60	0 41 15	+57 7·8	65·7	4, 7½	125·6+	6·75 −
4	34 Andromedæ	73	0 47 59	+22 55·5	66·0	4, 6½	349·5+	1·31 +
5	*251 P. O. Piscium	..	0 52 44	+ 0 4·9	52·8	8, 9	305·1+	18·80 ± ?
6	42 Ceti	113	1 13 9	− 1 11·5	63·0	6, 7½	343·0+	1·27 + ?
7	123 P. I. Piscium	138	1 29 15	+ 6 58·8	63·1	7, 7	28·7+	1·57 ± ?
8	586 B.A.C. Piscium	186	1 49 10	+ 1 12·1	63·8	7½, 7½	85·1+	0·30 −
9	α Piscium	202	1 55 18	+ 2 8·1	65·7	5, 6	325·7−	3·23 −
10	γ^2 Andromedæ B.C.	..	1 55 55	+41 42·4	65·7	5, 6·3	107·0−	0·59 ± ?
11	259 B Andromedæ	228	2 5 43	+46 52·9	62·9	7, 7	286·5+	0·90 −
12	257 Σ. Persei	257	2 15 53	+60 57·7	63·1	7, 8	183·5+	[0·40−]
13	ι Cassiopeæ A B	262	2 18 22	+66 49·0	62·9	4½, 7	265·8−	1·92 − ?
14	*278 Σ. Cassiopeæ	278	2 26 26	+68 43·7	57·9	8, 8½	67·6−	0·40 ± ?
15	114 B Arietis	305	2 40 9	+18 48·5	63·0	7, 8	321·7−	2·52 +
16	ι Arietis	333	2 51 46	+20 49·2	66·6	6, 6½	199·6+	1·14 +
17	7 Tauri A B	412	3 26 44	+24 1·7	65·7	7½, 7½	240·8−	0·50 −
18	*98 P III. Eridani	..	3 30 7	+ 0 9·8	45·8	6½, 9	235·9+	6·00 +
19	49 Cephei	460	3 48 23	+80 19·8	62·9	5½, 6½	15·6+	0·70 −
20	511 Σ. Camelopardi	511	4 7 1	+58 4·2	63·6	6, 7	294·7−	..
21	230 B Tauri	535	4 16 14	+11 1·3	63·0	7, 8	342·3−	1·73 ± ?
22	2 Camelopardi	566	4 29 39	+53 12·9	63·2	5½, 8½	299·5−	1·68 ± ?
23	577 Σ. Aurigæ	577	4 33 28	+38 15·2	62·7	7½, 8	265·5−	1·62 + ?
24	932 Σ. Geminorum	932	6 26 41	+14 50·8	63·4	8, 8½	333·2 −	2·26 ± ?
25	12 Lyncis, A B	948	6 34 44	+59 34·2	66·2	6, 6½	136·5−	1·64 +
26	α Canis Majoris	..	6 39 25	−16 32·4	66·2	1, 10	71·3−	10·10 −
27	38 Geminorum	982	6 47 18	+13 20·6	66	5½, 8	164·7−	5·70 −
28	1037 Σ. Gemin.	1037	7 4 42	+27 26·7	63·2	7, 7½	318·1−	1·22 ± ?
29	α Geminorum	1110	7 26 18	+32 10·4	65·3	3, 3½	241·4−	5·68 +
30	1157 Σ. Monoc.	1157	7 48 1	− 2 27·5	63·1	8, 8¼	256·7−	1·29 −
31	85 B Lyncis	1187	8 1 20	+32 36·3	66·1	7, 7½	56·3−	1·83 +
32	ζ Cancri A B	1196	8 4 45	+18 2·4	66·2	6, 7	234·6−	0·40 −
33	„ A C	..	..	..	66·2	6, 7½	140·7−	5·61 −
34	ι Hydræ	1273	8 39 53	+ 6 53·8	66·1	4, 8½	213·8+	3·87 ± ?
35	157 B Lyncis	1338	9 12 48	+38 44·2	66·1	6½, 7	142·5+	1·71 ± ?
36	ω Leonis	1356	9 21 29	+ 9 37·3	66·3	6½, 7¼	32·9+	0·30 −
37	*161 P. IX. Sext.	1377	9 36 42	+ 3 13·3	56·2	8, 10	129·4−	3·11 − ?
38	φ Ursæ Majoris	..	9 43 14	+54 40·2	66·4	5, 5¼	45·9+	0·24 −
39	8 Sextantis	..	9 46 4	− 7 29·5	60·3	6, 6½	38·2−	0·50 ± ?
40	γ Leonis	1424	10 12 47	+20 30·1	66·2	2, 4	111·4+	3·17 +
41	*145 B Leonis	1426	10 13 43	+ 7 5·0	56·1	7½, 8	271·7+	0·65 ± ?

No.	Name of Star.	Struve's No.	R.A. 1870.			Decl. 1870.		Epoch 1880+	Mag.		Position.	Distance.
			h	m	s	°	′				°	″
42	1457 Σ. Sextantis	1457	10	31	55	+ 6	24·9	63·2	7½,	8½	309·8 +	0·91 +
43	1516 Σ. Draconis	1516	11	6	28	+74	11·7	63·3	7,	7½	70·0 +	4·14 +
44	ξ Ursæ Majoris	1523	11	11	15	+32	16·0	66·3	4½,	5½	86·5 –	2·25 –
45	ι Leonis	1536	11	17	8	+11	14·9	65·4	4,	7½	72·1 –	2·81 +
46	191 B Virginis	1647	12	24	0	+10	45·7	63·2	7½,	8	212·9 +	1·39 +
47	γ Virginis	1670	12	35	5	– 0	44·2	66·3	4,	4	164·2 –	4·39 +
48	1678 Σ. Com. Beren.	1678	12	38	55	+15	5·4	60·3	6½,	7¼	204·3 –	31·07 –
49	35 Com. Beren.	1687	12	46	54	+21	57·2	65·3	5½,	8½	52·8 +	1·31 + ?
50	42 Com. Beren.	1728	13	3	40	+18	12·9	65·5	4½,	5	193·9 +	0·25 –
51	4530 B.A.C. Virg.	1757	13	27	39	+ 0	21·1	63·3	8,	9	59·0 +	2·00 ± ?
52	25 Can. Venat.	1768	13	31	53	+36	57·5	65·4	6,	7	round –	.. +
53	1785 Σ. Boötis	1785	13	43	16	+27	38·0	64·9	7,	7½	192·4 +	2·60 –
54	1819 Σ. Virginis	1819	14	8	48	+ 3	44·2	63·0	7½,	8	32·3 –	1·29 + ?
55	1830 Σ. Boötis	1830	14	11	33	+57	16·2	60·0	8½,	9	278·2 +	5·30 +
56	π Boötis	1864	14	34	36	+16	58·6	66·4	3½,	6	100·6 +	5·73 –
57	1876 Σ. Libræ	1876	14	39	31	– 6	50·6	63·3	8,	8	65·9 +	1·20 ± ?
58	ι Boötis	1877	14	39	18	+27	37·4	65·4	3,	7	325·5 +	2·92 +
59	ξ Boötis	1888	14	45	22	+19	38·5	65·7	3½,	6½	300·8 –	5·41 –
60	44 Boötis	1909	14	59	31	+48	9·7	63·3	5,	6	239·5 +	4·75 +
61	1 B Cor. Borealis	1932	15	12	43	+27	18·7	63·2	6,	6½	290·2 +	1·18 –
62	η Cor. Borealis	1937	15	17	50	+30	45·6	66·5	6,	6½	33·1 +	1·12 +
63	μ^2 Boötis	1938	15	19	36	+37	48·2	66·5	8,	8½	180·3 –	0·30 –
64	δ Serpentis	1954	15	28	36	+10	58·5	66·4	3,	5	189·8 –	3·42 +
65	γ Coronæ Borealis	1967	15	37	16	+26	42·5	66·5	4,	6½	round	..
66	51 Libræ A B	1998	15	57	13	–11	0·8	66·5	4½,	5	161·0 +	0·40 +
67	,, A C	..	..			..		65·5	4½,	7½	69·6 –	7·10 +
68	49 Serpentis	2021	16	7	14	+13	52·8	64·8	7,	7½	324·6 +	3·53 + ?
69	2026 Σ Herculis	2026	16	8	17	+ 7	42·4	65·4	8½,	9½	326·1 –	1·50 –
70	σ Coronæ Bor. A B	2032	16	9	49	+34	11·4	65·8	6,	6½	192·4 +	2·97 +
71	,, A C	..	..			..		62·6	6,	11	88·3 –	51·04 +
72	λ Ophiuchi	2055	16	24	21	+ 2	16·3	65·5	4,	6	25·2 +	1·51 +
73	ζ Herculis	2084	16	36	24	+31	50·1	66·8	3,	6	229·2 –	0·83 +
74	2106 Σ. Ophiuchi	2106	16	44	58	+ 9	37·9	63·5	6,	8	321·3 –	0·50 –
75	167 B Herculis	2107	16	46	42	+28	52·9	65·0	6½,	8½	189·3 +	0·93 –
76	*270 P. XVI. Ophiu.	2114	16	55	44	+ 8	38·5	59·3	6½,	7½	147·3 +	1·31 ± ?
77	210 B Herculis	2120	16	59	30	+28	16·1	66·4	6½,	9	272·9 –	3·56 +
78	μ Draconis	2130	17	2	39	+54	38·7	65·6	4,	4½	181·8 –	2·79 –
79	36 Ophiuchi	..	17	7	20	–26	23·9	62·4	4½,	6½	212·4 –	4·22 –
80	δ Herculis	2137	17	9	42	+24	59·7	66·7	4,	8½	179·6 +	20·18 –
81	ρ Herculis	2161	17	19	12	+37	16·1	62·3	4,	5½	309·5 +	3·61 ± ?
82	*5910 B.A.C. Ophiu.	2173	17	24	42	– 0	58·5	54·6	7,	7	150·5 –	1·37 +
83	μ^1 Herculis B C	..	17	41	23	+27	48·1	66·7	10½,	10¾	85·0 +	1·10 –
84	τ Ophiuchi	2262	17	56	0	– 8	10·6	66·7	5,	6	248·0 +	1·60 +

No.	Name of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° ′	Epoch 1880+	Mag.	Position. °	Distance. ″
85	70 Ophiuchi	2272	17 58 52	+ 2 32·5	66·6	4½, 7	101·1 −	5·27 −
86	α Lyræ	..	18 32 32	+38 39·9	65·6	1, 11	150·1 +	46·15 +
87	ι^1 (4) Lyræ	2382	18 40 0	+39 32·0	63·1	5, 6½	19·3 −	3·04 − ?
88	ι^2 (5) Lyræ	2383	..	..	65·8	5, 5½	142·6 −	2·35 ± ?
89	*2402 Σ. Serpentis	2402	18 43 30	+10 31·4	56·6	8, 8½	213·4 +	0·89 + ?
90	274 P.XVIII.Aquil. A B	2434	18 56 3	− 0 53·5	64·6	9, 9	136·8 −	24·29 −
91	,, B C	..	..	..	64·6	9, 10½	69·6 −	1·79 ± ?
92	2455 Σ. Vulpeculæ	2455	19 1 19	+21 58·9	64·9	7½, 9½	115·5 −	3·53 −
93	108 P. XIX. Drac.	2509	19 15 35	+62 58·3	62·9	6½, 8	343·7 −	0·80 +
94	δ Cygni	2579	19 40 54	+44 48·8	66·6	3½, 9	348·3 −	1·70 + ?
95	400 O. Σ. Cygni	..	20 5 40	+43 34·5	61·6	7½, 8½	316·7 −	0·62 − ?
96	*2696 Σ. Delphini	2696	20 27 6	+ 5 0·0	56·6	8, 8½	310·2 +	0·72 −
97	2708 Σ. Cygni	2708	20 33 45	+38 11·1	53·8	7, 9	340·5 −	16·00 +
98	λ Cygni	..	20 42 20	+36 0·8	67·0	6, 7	92·5 −	0·69 ± ?
99	*4 Aquarii	2729	20 44 32	− 6 6·7	56·8	6, 7	107·8 +	0·30 −
100	ε Equulei A B	2737	20 52 35	+ 3 47·9	66·7	5½, 7½	290·2 ± ?	1·06 +
101	„ A C	..	..	..	66·7	5½, 7½	73·1 −	10·55 − ?
102	61 Cygni	2758	21 1 4	+38 5·1	66·7	5½, 6	111·7 +	18·76 +
103	11 Arg. XXIV. Ceph.	..	21 11 4	+63 52·2	66·8	7¼, 7¼	244·5 −	0·98 +
104	20 B Pegasi	2799	21 22 58	+10 30·6	63·0	6½, 7½	317·5 −	1·44 +
105	33 P. XXII. Pegasi	2877	22 8 3	+16 33·0	63·6	6½, 9½	342·2 +	8·99 +
106	ζ Aquarii	2909	22 22 7	− 0 41·1	67·0	4, 4½	336·3 −	3·32 −
107	2934 Σ. Pegasi	2934	22 35 35	+20 45·1	63·8	7½, 9	164·7 −	1·21 ± ?
108	π Cephei A a	..	23 3 45	+74 41·1	65·7	5, 10	6·0 +	1·15 −
109	ο Cephei	3001	23 13 16	+67 24·0	62·5	6, 8½	182·1 −	2·28 − ?
110	69 P. XXIII. Aquar.	3008	23 17 2	− 9 10·4	63·0	8, 8½	262·8 −	5·59 −
111	8372 B.A.C. Cassiop.	3062	23 59 24	+57 42·3	65·7	6½, 7½	269·9 +	1·43 +

Part II. Suspected Binary Stars.

No.	Name of Star.	Struve's No.	R.A. 1870. h m s	Decl. 1870. ° ′	Epoch 1880+	Mag.	Position. °	Distance. ″
1	44 Σ. Andromedæ	44	0 31 8	+40 16·3	65·0	8½, 9	263·2 +	8·66 +
2	10 Arietis	208	1 56 16	+25 18·5	63·0	6, 8½	33·9 +	1·43 −
3	234 Σ. Cassiopeæ	234	2 7 47	+60 44·8	63·4	8, 8½	231·4 −	0·70 −
4	84 Ceti	295	2 34 33	− 1 14·8	64·0	6, 10	324·7 −	4·63 −
5	367 Σ. Ceti	367	3 7 18	+ 0 14·3	64·0	8, 8	257·1 −	0·50 −
6	η Orionis	..	5 17 56	− 2 31·1	66·9	4, 5	86·1 ± ?	0·95 ± ?
7	32 Orionis	728	5 23 49	+ 5 50·9	63·3	5, 6½	192·2 −	..
8	749 Σ. Tauri	749	5 29 6	+26 50·5	63·0	6¼, 6½	186·4 −	0·60 − ?
9	*15 Monocerotis A B	950	6 33 49	+10 0·9	52·1	6¼, 9	212·3 +	3·21 +
10	14 Lyncis	963	6 40 36	+59 35·9	63·4	6, 6	59·5 +	0·70 −
11	μ Canis Majoris	997	6 50 8	−13 52·6	64·0	5, 8½	337·2 −	2·76 −
12	13 P. XIII. Cancri	1202	8 6 26	+11 14·5	63·1	8, 10	327·4 −	2·50 + ?

No.	Name of Star.	Struve's No.	R.A. 1870.			Decl. 1870.		Epoch 1880+	Mag.		Position.	Distance.
			h	m	s	°	′				°	″
13	1216 Σ. Hydræ	1216	8	14	42	− 1	10·8	63·3	7,	7½	151·1 +	..
14	σ^2 Ursæ Majoris	1306	8	58	55	+67	39·7	63·2	6½,	9½	253·5 −	3·25 −
15	1316 Σ. Hydræ A B	1316	9	1	23	− 6	36·4	64·8	7,	11½	138·4 −	6·74 ± ?
16	116 B Hydræ	1348	9	17	37	+ 6	54·5	63·1	7½,	7½	328·1 −	1·66 +
17	*1357 Σ. Hydræ	1357	9	21	59	− 9	25·6	56·2	7,	10½	59·5 +	7·60 + ?
18	1500 Σ. Leonis	1500	10	53	15	− 2	44·4	60·3	7½,	8	315·8 −	1·15 +
19	1781 Σ. Virginis	1781	13	39	36	+ 5	46·0	65·7	7,	8	251·7 +	1·10 +
20	238 P. XIII. Virg.	1788	13	48	9	− 7	25·1	64·8	6½,	7¼	67·7 +	2·36 ± ?
21	121 B Boötis	1825	14	10	34	+20	44·2	64·4	7,	8	178·8 −	3·89 +
22	70 P. XIV. Libræ	1837	14	17	42	−11	4·6	65·0	7,	8½	314·1 −	1·34 −
23	1863 Σ. Boötis	1863	14	33	37	+52	7·4	64·3	7,	7	95·2 −	0·77 +
24	ζ Boötis	1865	14	34	56	+14	17·2	64·8	4½,	5	303·2 −	1·02 −
25	*260 B Boötis	1867	14	35	13	+31	50·8	49·4	8,	8½	18·5 −	1·33 −
26	1883 Σ. Boötis	1883	14	42	24	+ 6	30·5	63·3	7,	7½	262·7 −	0·80 −
27	1934 Σ. Boötis	1934	15	12	45	+44	15·7	64·8	8,	8½	38·1 −	6·05 +
28	1957 Σ. Serpentis	1957	15	29	46	+13	21·0	63·5	8,	9	155·7 −	1·53 +
29	21 Ophiuchi	..	16	45	19	+ 1	25·8	65·6	6½,	8	167·6 −	1·33 ± ?
30	3107 Σ. Ophiuchi	3107	16	51	34	+ 4	7·0	64·5	8,	8½	104·3 −	1·32 −
31	α Scorpii A a	..	16	21	26	−26	8·5	66·0	1,	8	272·9 −	2·92 − ?
32	281 B Herculis	2165	17	21	11	+29	34·5	64·6	7½,	8½	51·2 +	7·10 +
33	2199 Σ. Draconis	2199	17	36	12	+55	49·7	63·0	7,	7½	101·4 −	1·65 ± ?
34	μ^2 Herculis A B	2220	17	41	23	+27	48·1	66·7	4,	10½	243·9 +	31·19 +
35	*73 Ophiuchi	2281	18	3	6	+ 3	58·1	54·6	6,	7½	252·0 −	1·32 −
36	417 B Herculis	2289	18	4	21	+16	27·0	63·0	6½,	7½	234·3 −	1·24 ± ?
37	*2384 Σ. Draconis	2384	18	38	36	+66	59·1	54·8	8,	9	332·8 +	0·35 −
38	2437 Σ. Sagittæ	2437	18	56	15	+18	58·8	63·0	7½,	7½	71·4 −	0·80 −
39	2454 Σ. Lyræ	2454	18	59	46	+30	11·8	65·3	8,	9	225·9 +	1·26 +
40	22 B Cygni	2525	19	21	30	+27	3·1	65·2	7,	7½	240·8 −	0·60 −
41	2544 Σ. Aquilæ A B	2544	19	30	53	+ 8	1·3	64·2	7,	9½	208·9 −	1·20 +
42	2556 Σ. Vulpeculæ	2556	19	33	50	+21	26·3	64·9	7,	7	167·7 −	..
43	2576 Σ. Cygni	2576	19	40	40	+33	18·4	63·3	7½,	8¾	308·8 −	3·27 −
44	*2640 Σ. Draconis	2640	20	3	4	+63	31·3	41·8	7,	11	23·2 −	4·99 +
45	2744 Σ. Aquarii	2744	20	56	27	+ 1	1·3	63·2	6,	7	177·5 −	1·50 ± ?
46	2746 Σ. Cygni	2746	20	55	22	+38	33·3	63·3	8,	9	283·7 +	0·80 − ?
47	*2760 Σ. Cygni	2760	21	1	27	+33	36·7	51·9	7,	8	223·9 ± ?	10·90 −
48	50 P. XXI. Cygni	..	21	9	21	+40	36·9	59·7	7,	7¼	126·4 −	1·02 − ?
49	29 B Pegasi	2804	21	26	57	+20	8·6	64·9	7,	8	324·5 +	2·75 −
50	*37 Pegasi	2912	22	23	24	+ 3	46·4	57·1	6,	7	117·5 +	0·74 −
51	2928 Σ. Aquarii	2928	22	32	38	−13	17·0	63·1	8,	8¼	319·3 −	4·38 −
52	219 P. XXII. Aquar. A C	2944	22	41	8	− 4	54·1	62·7	7,	8	146·6 −	50·67 −
53	2976 Σ. Piscium B C	2976	23	1	26	+ 5	54·2	57·4	9½,	10	183·2 +	16·31 +
54	3046 Σ. Ceti	3046	23	50	0	−10	12·7	63·9	8,	8¼	241·5 +	2·90 +
55	37 B Andromedæ	3050	23	52	48	+33	0·3	64·8	6,	6½	199·5 +	3·17 −

Notes to Part I.

1. 316 B Cephei. Epoch of distance = 1857·5.
12. 257 Σ. Persei. Epoch of distance = 1857·5.

51 Libræ. Perhaps the measures of A C ought rather to be put in Part II., the reality of a change not being assured. There is some confusion in the designation of this star: Brothers at the instigation of Dawes terms it ξ Scorpii, as also did Smyth, but in retaining the appellation "51 Libræ" I have followed the better supported usage.

5910 B.A.C. Ophiuchi. Secchi gives, as measures of Position angles, W. Struve, 1830, 323°; Mädler, 1843, 166°; and himself, 1858, 325°, and hints at Mädler having made a mistake of 180°.

Dawes gives Struve as above; many by himself all about 160°, and Mädler 1854, 150°.

The true explanation would seem to be that different observers had treated, some one and some the other star as A. The magnitudes of the components being nearly or quite identical, this is not matter for much surprise.

2708 Σ. Cygni. A diminution of 20° in the angle of position in thirty years, 1823–53, is clearly established; but the change in the other element is far more marked. The distance has, in like period, increased from 9″·5 to 16″·0 an amount which is very noticeable by reason of its magnitude.

Note to Part II.

2760 Σ. Cygni. In the twenty-six years, 1825–51, the position remained absolutely identical, but the distance diminished with extreme regularity from 14·3″ to 10·9″.

On some Markings seen on Venus. By John Browning, Esq.

On the afternoon of the 14th of March I had been watching some Sun-spots with Mr. Barnes' 10½-inch silvered-glass reflector. The Sun being obscured by some trees, about 5 o'clock I set *Venus* off on the circles, and found definition better than usual. Knowing the exact direction in which to look, I now saw that the planet was visible to the naked eye. Returning to the telescope, I saw a long gradation of light from the terminator, and the extreme edge appeared unsymmetrical. Regarding the planet more attentively, I perceived a faint mottling which extended inwards from the terminator across more than one-third of the visible disk. These markings caused the planet to look something like the Moon, when it is seen faintly with a low power, in a small aperture, through a mist.

The drawing which I have now the honour to exhibit before the Society represents the appearance I have described as nearly as I have been able to portray it; but it should be viewed by oblique light, and held at some distance from the eye.

The northern horn of the planet is somewhat bulged near the termination, and then blunted just at the extremity. This I have since been able to verify.

A white spot will be noticed near the edge of the disk, opposite the terminator. This was probably caused by a cloud, such as I have often seen on *Mars;* where, when they are near the edge of the disk, they rival the ice-caps in brilliant whiteness.

On a subsequent occasion, when observing *Venus* with my own 12¼-in. silvered-glass reflector, I found the air even steadier than on the evening that I made the drawing. I had steady definition with whole aperture, and power 400; yet I could not perceive any markings on the disk. From this I conclude that the visibility of the markings depends on some peculiar condition of the planet's atmosphere.

I think I am justified in saying that *Venus* is better shown by a good reflector than by an achromatic. I do not say this only because I see it myself better; but because, at different times, I have been told by Messrs. De La Rue, Le Suer, and With, who all used reflectors, that they have made out markings on the disk of the planet, while the late lamented Mr. Dawes could never see any markings with an achromatic.

A reflector of large aperture used with a single surface reflecting eye-piece, gives, I believe, the best definition at present obtainable of this difficult object.

I propose to use such an arrangement constantly for the next few months, and trust I may be enabled to bring some more definite results before the Society.

On the Lustre of Venus. By C. H. Weston, Esq.

Sir John Herschel, in his *Outlines of Astronomy* (Art. 467), remarks that *Venus* appears occasionally in the western sky after sunset with dazzling lustre, and in favourable circumstances may be observed to cast a pretty strong shadow; and adds in a note, that such "must be thrown upon a white ground."

On the 15th inst. the sky was very clear, but subject to occasional local condensations. *Sirius*, *Orion*, and *Venus* came out with striking brilliancy; for the humid state of the atmosphere, so long as it remained transparent, necessarily produced great optical exaggeration of the heavenly bodies.

About 8 o'clock P.M. when *Venus* was in the north-westerly part of the sky, and myself and others were passing along a wall at right angles with the planet, we were struck with the shadows of all the figures projected on the wall by the vivid light which *Venus* then exhibited. I directed especial attention to the fact as one of not very usual occurrence; and the more worthy of note because the wall possessed neither whiteness nor smoothness of surface. It was built of rough stone containing much iron, which had given to it by long exposure a decidedly ferruginous brown colour, and its face was also very uneven. As the pillars of the gateway consisted of worked Bath stone with level surfaces, I was desirous of testing more carefully the shadows thrown upon them, and here I could detect the shadow of my walking-stick, although even the worked stone was turned to a brownish white by atmospheric influence.

Of course, in the present instance, the relative position of the wall and the planet offered great advantages for the perception of shadows. Had they been at a considerable angle to each other, the delicate shadows would have been cast too far from the figures to have attracted notice, and the defining outlines of such would also have been less marked.

The wall and the gate pillars were in a clear atmosphere, on an elevation about 740 feet above the mean sea-level.

That shadows should have been cast by *Venus* in her present optical position is the more remarkable because she will not attain her greatest brilliancy (before her inferior conjunction) until 9th June.

How decided therefore (under similar favourable conditions) would these shadows have been, had they been cast by *Venus* in the greatest brilliancy of her eastern elongation upon a smooth and whitewashed wall, as suggested by Sir John Herschel.

Ensleigh Observatory, Lansdowne (above) Bath,
***March* 16, 1868.**

Description of Zenith Telescope of U. S. Coast Survey.
By G. Davidson, Esq.

(***Extracts from two Letters to Prof. Piazzi Smyth, Astronomer Royal for Scotland.***)

When I had the pleasure of visiting you in Edinburgh last June, I promised to send you a drawing of one of our improved Zenith Telescopes, for the determination of the latitude.

I had not forgotten it, but it has been impossible to have the drawing made, on account of the great pressure of business consequent upon Dr. Bache's illness.

I inclose you a drawing that is at least effective, if not very artistic, and at the same time give a short description of the instrument and methods of observing, with the formulæ for the reduction of the observed results.

The instrument was first devised by Capt. Andrew Talcott, of the U.S. Corps of Engineers, to practically carry out the principle based upon the proposition that, when the meridian zenith distances of two stars, at their upper culmination (one being north and one south of the zenith) are equal, the colatitude is the mean of their north polar distances. It is, therefore, necessary, to avoid arc readings, that the telescope, when pointed to any zenith distance, should be capable of being revolved on a vertical axis. And as two stars could rarely be found having the same meridional zenith distance, those are selected in pairs (N. and S.), which culminate within a few minutes of time and within twenty minutes (of arc) of zenith distance of each other, and the difference of meridional zenith distance is measured by a micrometer, and changes of verticality by a delicate level.

Many improvements have been made by officers of the Coast Survey, where its value was at once appreciated; and its latest form is that proposed by the late R. H. Fauntleroy, Esq., of the Coast Survey, whereby stars in the zenith can be observed, and transit observations also made for time with the requisite accuracy.

The drawing gives a fair idea of the instrument with the latest improvements. The telescope is usually about 45 inches focal length; object-glass 3¼ inches diameter; magnifying power used about 100, by which we obtain nearly all the stars in the B.A.C.

Stops are clamped on the azimuth circle to denote when the instrument is on the meridian N. and S. The telescope is set to the nearest minute of the apparent mean zenith distance of the two stars; the star bisected at culmination by micrometer line, and micrometer and level read. Telescope revolved 180°, and second star observed in precisely the same manner. We allow five minutes between stars, and seven minutes between pairs.

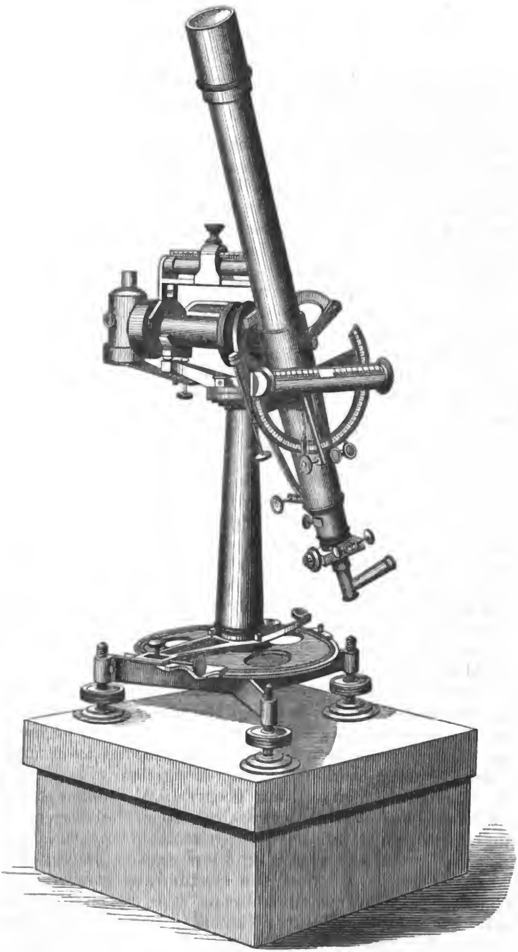
All accuracy depends upon the delicacy of the level and micrometer, and these have been particularly studied, and their values very minutely determined.

Our results show that one observation (N. and S.) is as good as the average places of the B.A.C. But I cannot enter into too much detail, and will merely refer you to a very full article on the subject in Chauvenet's *Spherical and Practical Astronomy*, pp. 1350, published here in Philadelphia.

[Here follow certain formulæ for reduction, &c. extracted by the writer from his manuscript investigations and instructions.]

Germantown, Pa., U.S.A.,
Nov. 17, 1865.

About the matter of the Zenith Telescope, you are perfectly at liberty to use anything I have written or write to you about it; and I have interested myself in the matter since receiving your note, so that I hope to receive in two or three weeks an engraving of the instrument from the groundwork of what I sent you. I have written to Prof. Benjamin Peirce, Superintendent U. S. C. S., upon the subject, and he authorises me to say that if you, or any parties, desire a Zenith Telescope constructed, he will have the work upon it superintended by a Coast Survey officer, and will specially see that all the "improvements" of the instrument, as developed in field operations, are specially attended to, and adopted. I have inquired of the maker who constructs all ours, and have from him the following reply:—



Zenith Telescope of the United States Coast Survey. Prof. A. D. Bache, Supt.

Zenith	Telescope of	30-inch	focal	length	850	dollars.
,,	,,	36	,,	,,	950	,,
,,	,,	45	,,	,,	1200	,,

He has one of 51 inches focal length, which he will sell at the price for making a 45-inch. The above rates are in the U.S. legal tender currency.

After using the 45-inch telescopes for years, I am constrained to say that their weight oppresses me on mountain duty, and I prefer one of the smaller. I will obtain for you some of the results obtained by a 30-inch. In the meantime I think a 36-inch telescope would be the best under all circumstances. The overseeing of the making of the instrument by the Coast Survey would, of course, be gratuitous.

When I send you the engraving, I will try to add a copy of all the formulæ, &c., lest I overlooked anything in my former description, which was hurriedly drawn up. In latitude observations I have no hesitation in saying, after twenty-two years' practical experience in using prime vertical transits, vertical circles, and Airy's zenith sector, that the zenith telescope of the Coast Survey stands far above them. The elaborate discussion of the results obtained by all the different methods has developed the same conclusion.

In such work as I have been engaged in upon the Alaska Coast, and expect still further to carry forward, I am evolving an instrument to combine the properties of the portable transit and zenith telescope. I inclose you an engraving of the Coast Survey portable transit, with telescope of 36 inches focus. The broad idea covering my proposed instrument is to have a double horizontal frame, or one beneath that of the transit; one revolving upon the other with a short central vertical hollow axis. When to be used as a transit, the two horizontal frames are securely clamped together: when to be used as a zenith telescope, these screws are unclamped, and the instrument will revolve in azimuth, with stops on each side, to which the upper part is brought, to make the telescope play in, or very near, the plane of the meridian. This instrument will also be very useful in determining the azimuth of a mark by circum-elongation of a close polar star. This is necessary in our geographical reconnaissance of a coast where bad weather may close upon the observer when changing his transit and setting up a zenith telescope. I put my transit in the meridian generally in less than 1½ hours; observed eight or ten transits for time and instrumental corrections; then obtain ten pairs of zenith telescope stars for latitude, which usually has a probable error of less than 0″·2. The instruments are generally removed by one or two o'clock A.M., and the vessel at another station 50 or 60 miles off during the day, and ready for another set of observations at night.

Where the latitude is required for a main triangulation station, the zenith telescope observations embrace about five observations upon as many different nights (*i.e.* one observation per night) upon thirty pairs of stars. Of course this supposes that the places of the stars are well determined. We use the B.A.C. as a field basis, and after the stars are selected for work, the corrections to their B.A.C. places are used in the computations.

Germantown, Pa., U.S.A.,
February 11, 1868.

Observations of the Lunar Crater Linné.
By the Rev. T. W. Webb.

The very unfavourable weather which we have had for a long time has prevented me from turning to much account the very superior defining power of the 9¼-inch silvered speculum by Mr. With, now in my possession; but I have had a few views of the spot *Linné*, in addition to one which was made known at an early period, and the most satisfactory of these I beg permission to communicate to the Society, in the hope that they may be received as a slight addition to the evidence which is being accumulated as to the nature of this mysterious object.

1867, Nov. 17^{d} 18^{h} 30^{m}. Power about 170. Definition very fine, though a little fluttering. At, or very near, *Linné*, a minute, white, not especially brilliant speck stands exactly on a dark grey terminator, quite insulated, and not surrounded by any white cloud. It is impossible to say whether it is *Linné*, but from comparison with Lohrmann I believe it to be so.

1867, Dec. 16^{d} 18^{h} 45^{m}. Power 170. Air very fluttering and often clouded. Terminator through W. wall of *Maurolycus* and *Aristoteles;* a very little beyond *Bessel.*

Linné an inconspicuous object; the white cloud has become very faint, and is ill bounded; at its E. edge is a small speck of greater brightness, apparently a minute hill; but definition is too unsteady.

The preceding observations were in waning illumination, as the dates will show. In the next it was enlightened the opposite way.

1868, Jan. 1^{d} 7^{h} 30^{m}. Power about 212. Air very steady, but constant clouds of varying thickness. Terminator through the pass between *Caucasus* and the *Apennines;* the E. edge of the *Mare Serenitatis* next *Apennines* is, however, still in shade.

Linné. A very hasty view seemed to show a crater of several seconds in diameter, with a shallow white interior, and a very narrow shadow on the W. side; but the cloud became too thick before it could be verified. It may have been about the size represented by Lohrmann.

The next observation was two days only before full.

1868, Jan. 7^{d} 9^{h} 30^{m}. Power 170. Sharp, but fluttering, and very frequently clouded. Terminator bisecting *Seleucus*, and half its own breadth beyond *Phocylides*.

Linné neither so large nor so bright as *Posidonius* γ. Each, but most certainly *Linné*, seems to have a minute brighter spot in the centre.

The next two were in the wane.

1868, Jan. 14^d 19^h 15^m. Power 170. Sharp and clear, but often obscured by cloud. Terminator through W. edge of *Cyrillus* and *Catharina*, and the Serpentine Ridge of *M. Serenitatis*.

Linné. A white spot, not very large or bright, with something brighter in its centre, not very readily seen. It was a little E. of the centre, and looked, as far as I could judge, like a very small white hill.

1868, Jan. 15^d 19^h 20^m. Power 110. Generally thick haze; often cloud; bad definition in a few clear intervals. Terminator about two-thirds diameter of *Autolycus* beyond *Linné*.

Linné. I was for a long time deceived by mistaking for this object *Linné* B, which was a little beyond the terminator; and it was not till I had examined the map that I perceived my error: it had then become cloudy, and had it continued so, I should have believed that nothing had been visible on the site of *Linné* except some grey mounds; but fortunately a clear interval of a few minutes enabled me to repeat the observation; when I found in the right position a very small white spot, very much smaller than the white cloud, of which there was not a trace; though distinctly defined upon the dark grey surrounding level, it was by no means a bright object. It was, I think, elongated N. and S., and had the aspect of a hill, but perhaps more from prepossession than any real evidence, for under present definition it was impossible to be certain of any shadow on the W. side. A winding grey ridge passed from S. to N. between it and the terminator, which it touched N.W. of *Linné*, and then returned in a less connected form towards E. The white hill was so far from it, that I question whether the cloudy patch, if visible, would do more than reach the foot of the ridge.

The last observation was in increasing illumination, 2^d after first quarter.

1868, Feb. 3^d 7^h 15^m. Power 212. Sharp, but unsteady definition. Terminator two-thirds across *Sinus Iridum*, of which the whole border is enlightened.

Linné is decidedly less bright than *Posidonius* γ. I sometimes fancied I saw a trace of the shadow of the W. side of a low ring, as large as that drawn in the map; but my impression was faint, and while writing subsequently I feel less certain about it than I could wish.

10^h 30^m to 11^h 15^m. Definition has become unusually beautiful, though not perfectly steady, and clouds frequently interrupt the observation. *Sinus Iridum* all enlightened, but E. part in heavy penumbra. *Linné* at best moments,—in fact usually, is very distinctly seen as a minute deep crater with black interior shadow and bright ring: once or twice I even fancied I could see part of the bottom in bright illumination; but of this I could not be certain. It lies in the centre of the white cloud, of which it occupies $\frac{1}{3}$ or $\frac{1}{4}$. I thought it bore about the same proportion to the neighbouring crater *Linné* A, but I did not at the time make a direct comparison of the cloud and this crater. It was, I think, about the size of the minute crater *n. f.* the N. end of the *straight wall*, and could not have exceeded,—probably did not attain,—1″ in interior diameter. It was seen, but not so well, with a power of 450; the eye-piece, however, was not quite equal to the other (a microscopic doublet of admirable sharpness), and the air might have changed.

This last observation is sufficiently remarkable, from the evidence afforded by the distinct black shadow, of the extraordinary depth and steepness of the crater, above which the sun could not have been elevated much less than 50°.

Hardwick Parsonage, Feb. 8, 1868.

The Lunar Crater Linné. By Edward Crossley, Esq.

On Monday evening, March 30th, 1868, I had an excellent opportunity of viewing *Linné*. Age 6·6 days; aperture $9\frac{1}{3}$ refractor. Equatoreal by Cooke.

With low powers the shadow of the central eminence was easily seen. With 240 it was plainly resolved into a small crater, and with 470 the crater was brought out into as strong relief as any of the other craters on the *Mare Serenitatis*. It appears to be about a mile in diameter.

The obscuration round the crater is very much subdued to what it was last year, and appears circular, and somewhat dished, but badly defined at the edges.

In October 1867, the Moon waning, with the terminator on Bessel, and with the same power and aperture, I could only make out the shadow of an eminence in the centre of *Linné*.

On the Tuesday evening, March 31st, 1868, though the Moon was a day older, the central crater was quite an easy object.

Halifax, April 1st, 1868.

The Lunar Crater Linné. By Capt. Noble.

The night of Monday, the 30th of March ult., being peculiarly fine, I occupied myself from $8^h\ 20^m$ to 9^h L.M.T. in the examination of *Linnæus;* employing powers of 154 and 255 in my 4·2-inch Equatoreal for that purpose.

The detail was even better and more sharply seen than on the 3d of last November, and the outline of the wall of the crater was exceedingly plain. The west and south-west portions of this wall cast a distinct shadow in the interior: no such shadow, however, was projected by the east wall on the surrounding *Mare*. Hence it is evident that, shallow as is the western half of the ring, the eastern is shallower still. I could see nothing of the minute crater. The Moon's age at the mean epoch of this observation was 6·56 days.

At 11^h 10^m L.M.T. I returned to my scrutiny of *Linnæus*. The shadow of the western wall had disappeared, and it was only by sustained attention that *Linnæus* could be made out as a crater at all. A cursory glance showed it as a nebulous spot. The Moon set about 20 minutes after midnight, but I am persuaded from what I saw, that very shortly afterwards nothing but the well-known hazy, ill-defined patch can have occupied the place of *Linnæus*, in every locality where the Moon was above the horizon.

Forest Lodge, Maresfield, Sussex,
8th April, 1868.

Proposal for a new Star Atlas.

By R. A. Proctor, B.A.

It appears to me that a series of star-maps fulfilling the following conditions would form a desirable addition to scientific libraries:—

The series should consist of

I. A moderate number of maps,
II. Not too large for convenient use,
III. Uniform in size and shape,
IV. On the scale of an 18-inch globe (at least),
V. With little distortion, and
VI. With little variation of scale or area,
VII. On a *central* projection or construction uniform for each map; and
VIII. Exhibiting satisfactorily the connection between the different maps of the series.

A little consideration will show that all these conditions are important, and some of them essential for charts intended to occupy a space midway between popular maps and such charts as Argelander's. Accordingly it would not suffice merely to increase the scale of any extant popular maps. The effect of such a process is seen in the large maps of the Society for the Diffusion of Useful Knowledge, which are not only too unwieldy for convenient use, but represent small star-groups with preposterous distortion. In fact, the gnomonic projection, which has valuable properties for popular maps, seems wholly unsuited for maps of a higher class. The astronomer seeking to master the configuration of small star-groups, the depths within which he proposes to explore, requires more efficient aids than "straight-line pointing," which may co-exist (as every mathematician knows) with the most egregious distortion and scale-variation.

The stereographic projection is far superior to the gnomonic for such purposes as we are now considering. But there is a somewhat rapid scale-variation in this projection, which is likely to prove misleading. It will be found difficult to propose any plan for stereographic maps in which the variation of scale and area would be nearly so small as in the construction I am about to propose.

My plan is to divide the sphere into twelve spherical pentagons, the centres of which would be the angular points of a dodecahedron inscribed within the sphere. The poles of the sphere should be the centres of two of the pentagons.

It will be observed that this mode of dividing the sphere is that adopted in my gnomonic star-maps. But, instead of the gnomonic projection I propose the use of the equi-distant construction; and I suggest, also, that the small circles surrounding each spherical pentagon should be made the boundaries of the twelve maps.

The scale-variation in the above arrangement would be exceedingly small: it would clearly be represented by the ratio of the *spherical* radius to the *true* radius of the small circle bounding each map; *i.e.* by the ratio

$$\sin\ 37^\circ\ 22'\ 38''\cdot 5 : \text{arc}\ \ 37^\circ\ 22'\ 38''\cdot 5$$

or

$$40 : 43$$

very nearly. This ratio would also represent the variation of area.

I send with this the half of a polar and the half of an equatorial map, on the scale of an 18-inch globe, divided to every degree of arc. The equatorial map was drawn as follows: the position of the point of intersection of every fifth circle of right ascension with every fifth declination-parallel was calculated by the usual spherical formulæ, and marked down, accordingly, in the map.

Of the ten equatorial maps, only two would have their *dark* circles of R.A. in the position shown in the half-map. In all other respects the lines of R.A. and declination would be alike in the ten equatorial maps.

Maps on this scale might contain all the 8377 stars of the B.A. catalogue, and at least 2000 nebulæ. I would suggest the reduction of star-places to the year 1880 as in my star-maps. Perhaps, also, the introduction of the heliocentric orbits of the planets would make the series more useful.

The connexion of the maps would be sufficiently indicated by the overlapping segments; or, my gnomonic maps might be used as index-plates.

The boundaries of the constellations would have to be introduced, but I think the constellation-figures should be omitted. They would disfigure a scientific atlas. If my small maps were used as suggested, all that would be required in this way would be supplied.

The addition of duplicate maps showing the stars only on a black back-ground would, I think, be desirable.

The longitude and latitude lines would not be required, as every observer is, doubtless, familiar with the processes for reducing R.A. and declination to longitude and latitude, and *vice versâ.*

I would suggest also the addition of a short line at the intersections of every fifth meridian and parallel,—such line indicating, by its length and direction, the amount and direction of the precessional change for 100 years (say) at that point of the celestial sphere.

The labour of drawing the meridians for each map could be saved by instructing the engraver to draw the meridians and parallels of one polar and one equatorial map; and to take a sufficient number of impressions of these *on dry paper* (to avoid shrinkage). On these impressions the stars and constellation-boundaries could then be drawn in by whoever undertook the construction of the maps.

The reduction of star-places to 1880 (to the degree of accuracy required) would not take long. In my *Handbook of the Stars* there are the reduced places of 1500 stars extracted from the B. A. Catalogue. It may be noticed that the reduction is simplified when it is made for thirty years, since we have only to halve the correction in *seconds* and estimate the result as *minutes.*

The *Annals of the Astronomical Observatory of Harvard College,* published up to this date, are—

Vol. I. Part I. History and Description of the Observatory;
Vol. I. Part II. Zone Catalogue of 5500 Stars;
Vol. II. Part I. Observations of the Planet *Saturn;*
Vol. III. Account of the Great Comet of 1858;
Vol. IV. Part I. Catalogue of Polar and Clock Stars. There is now published, 1867;
Vol. II. Part II. containing the Second Series of Zone Observations, of which the first series is continued;
Vol. II. Parts II. III. and IV. are yet unpublished; and
Vol. V. entitled Observations upon the Great Nebula of *Orion* by the late G. P. Bond, Director of the Observatory of Harvard College, edited by Truman Henry Safford, Director of the Dearborn Observatory of Chicago, Introd. pp. viii. to xxvi., text pp. 1 to 189.

The observations given in the volume were commenced by Prof. G. P. Bond in the year 1857. During that winter and the next spring they were continued so far that most of the stars between the limits of the R.A. of the catalogue contained in the work, and within 20′ of Decl. of the trapezium were already observed. Owing, however, to the apparition of Donati's Comet (and also partly to the decease of Prof. W. C. Bond in 1859), the work of reduction was discontinued, and suffered an interruption of some years. But as soon as vol. iii. was finished, Prof. G. P. Bond returned to the nebula of *Orion*, and from that time until his death in 1865, devoted much of his time and of his gradually failing strength to that object.

The work was left unfinished at the author's death, and the completion as far as possible, and publication, were left to the editor. It was, therefore, necessary for him to complete those portions which were so far advanced that the form which Prof. Bond desired to give them could be recognised, and for the remainder to give as far as possible the original observations as they stood in the records of the Observatory, with the amount of reduction necessary for astronomers to derive as much advantage as possible from them.

The charts and engraving executed by Mr. Watts under the author's personal supervision are appended to the engraving of the nebula not completed in 1864, and the edition of it printed.

A drawing by Prof. W. C. Bond, from which an engraving was made for vol. iii. new series, *Mem. American Academy*, was given to Mr. Watts to re-engrave, as the original engraving did not appear sufficiently accurate, and the differences between the two are of some importance in respect to controverted points. It was, however, found an extremely difficult task to reproduce the original drawing.

Elements of Minor Planets (94) and (95).

The following elements calculated by Dr. Tietjen are given *Ast. Nach.* No. 1863.

	(94).		(95).	
	1867, Nov. 28·0, Berlin M.T.		1868, Feb. 12·0, Berlin M.T.	
M =	340° 30′ 39″·5	Mean Eq. 1867·0	39° 23′ 39″·3	Mean Eq. 1868·0
ω =	40 50 23·2		144 33 46·1	
☊ =	4 32 9·3		244 20 50·3	
ι =	8 5 27·0		12 52 6·5	
ϕ =	5 10 18·6		8 32 13·3	
μ =	630″·5129		659″·8598	
log a =	0·500208		0·487037	

ERRATUM IN LAST NOTICE.

Page 154, *for* H. C. Key, Esq. *read* the Rev. H. Cooper Key.

CONTENTS.

Page
Fellow Elected 165
On the Rejection of Discordant Observations, by Mr. Stone .. .. ib.
Note on the Employment of the Table given in the *Nautical Almanac* "showing the Correction required on Account of Second Differences in finding the Greenwich Time corresponding to a reduced Lunar Distance," by Capt. Shadwell, R.N... 168
Occultations of Stars by the Moon, and Phenomena of *Jupiter's* Satellites, observed at the Royal Observatory, Greenwich, from January to December, 1867 172
A Synoptical Catalogue of known and suspected Binary Stars, by Mr. Chambers 174
On some Markings seen on *Venus*, by Mr. Browning 179
On the Lustre of *Venus*, by Mr. Weston 180
Description of a Zenith Telescope of U. S. Coast Survey, by Mr. Davidson 181
Observations of the Lunar Crater *Linné*, by the Rev. T. W. Webb .. 185
,, ,, ,, by Mr. Crossley 187
,, ,, ,, by Capt. Noble.. .. .. ib.
Proposal for a New Star Atlas, by Mr. Proctor 188
Notice of Annals of the Harvard Observatory 190
Elements of Minor Planets (94) and (95) by Dr. Tietjen 191
Erratum .. .. ib.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *May* 8, 1868. No. 7.

Admiral Manners, President, in the Chair.

Isaac Patchett, Esq., Birstall Academy, Leeds,
was balloted for and duly elected a Fellow of the Society.

Occultations visible in the Month of August, 1868, *at Madras, and along the Shadow Path of the Total Eclipse of the Sun in India.* By C. Ragoonatha Chary, First Assistant at the Madras Observatory.

(*Communicated by N. R. Pogson, Government Astronomer at Madras.*)

In consideration of the importance attached to the coming great Solar Eclipse of August next in the Indian Peninsula, and of the interest evinced by Her Majesty's Government and by scientific Societies to secure observations calculated to throw light upon the physical constitution of the Sun, I have taken the liberty of communicating the prediction of certain occultations which will, I trust, be deemed worthy of insertion in the *Monthly Notices* of the Society.

It may not be out of place here to mention that approximate calculations for twelve stations on the central line have been made by me, and that two maps, showing respectively the track of the Moon's shadow across India, and the positions of such stars and planets as will most probably be visible to the naked eye, have been prepared in conformity therewith. My results, together with a popular description of the usual phenomena of a total eclipse by N. R. Pogson, Esq., Government Astronomer, have been published in the Madras Almanac of the Male Asylum Press, and seven spare copies of the same, in pamphlet form, are herewith forwarded for distribution, and review in the *R. A. S. Monthly Notices*.

As it is intended that several competent observers shall be stationed in different localities along the central line in the Indian Peninsula to secure noteworthy observations of this great phenomenon, and as it is also probable that these observers may have to remain in their places some days prior and subsequent to the date of the occurrence of the eclipse, to ascertain their geographical positions, &c., it occurred to me that, by means of corresponding observations of the occultations of stars by the Moon at the Madras Observatory, as well as at the different places in the track of the shadow at which the eclipse may have been recorded, the terrestrial longitudes of such stations might be pretty accurately determined.

In the hope that such preliminary calculations may prove useful, I have selected such stars only as can be easily observed; and these, twelve in number, will suffer occultation in the month of August, and will be equally visible at Madras and throughout the shadow line. The times of disappearance, reappearance, and the points of contact for these stars, are computed for three equidistant places on the centre line; one on the western coast near Viziadroog, another in the middle near Muktull, and the third on the eastern coast near Masulipatam. As the shadow crosses India nearly along the same parallel of latitude, the variations in time, &c., for the intermediate stations will only be affected by the difference of longitude, and such variations I have therefore given, both for disappearance and reappearance, for each occultation computed. They will enable observers to ascertain easily and approximately the times and points of contact for all intermediate stations.

The tabulated results have been obtained exclusively by the aid of the slide-rule. They are not likely to be uncertain by more than half a minute in time, or a degree in the angular points of contact.

For the Madras Observatory.

			Disappearance.			Reappearance.		
1868.	Star's Name.	Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 58·8	110 E	58 L	15 4·8	151 W	146 L
3	29 Capricorni	5	12 4·8	48 E	54 L	13 44·0	94 W	132 R
4	38 Aquarii e^2	6	17 37·9	69 E	3 R	18 43·3	114 W	171 L
10	μ Ceti	4	11 17·4	78 E	156 L	12 16·0	121 W	42 R
12	1406 B.A.C.	7	12 38·1*	78 E	154 L	13 32·5	112 W	33 R
12	Aldebaran	1	13 37·3	71 E	150 L	14 38·6	108 W	25 R
14	12599 Lalande	8	14 18·3*	65 E	140 L	15 8·4	82 W	3 R
14	12650 Lalande	8	14 58·3	38 E	116 L	15 37·9	56 W	25 L

			Disappearance.			Reappearance.		
1868.		Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 19	21487 Lalande	7½	7 10·3	163 E	86 L	7 41·2*	123 W	161 L
22	xiii. 1016 Weisse's Bessel	8	9 34·6	65 E	11 R	10 17·9*	35 W	113 R
23	ξ′ Libræ	6	7 20·7	128 E	68 L	8 34·9	94 W	163 R
25	5579 B.A.C.	5	8 46·3	151 E	98 L	9 38·0	137 W	161 L

* Star below the horizon.

For East Longitude 73° 30′ and North Latitude 16° 35′.

			Disappearance.			Reappearance.		
1868.	Star's Name.	Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 9·1	86 E	49 L	14 37·9	126 W	179 L
3	29 Capricorni	5	11 30·5	28 E	48 L	12 50·2	69 W	82 R
4	38 Aquarii e^2	6	17 9·5	48 E	17 R	18 15·0	95 W	166 R
10	μ Ceti	4	10 55·0	65 E	137 L	11 52·3	106 W	31 R
12	1406 B.A.C.	7	12 16·1	63 E	134 L	13 7·8	95 W	21 R
12	Aldebaran	1	13 15·3	53 E	127 L	14 10·0	88 W	10 R
14	12599 Lalande	8	13 59·7	45 E	115 L	14 36·8	61 W	13 L
14	12650 Lalande	8	14 50·7	5 W	69 L	14 54·4	13 W	63 L
19	21487 Lalande	7½	6 36·3	154 E	79 L	7 16·8	111 W	176 L
22	xiii. 1016 Weisse's Bessel	8	9 10·3	45 E	27 R	9 39·6	13 W	87 R
23	ξ′ Libræ	6	6 33·6	122 E	75 L	7 56·4	83 W	144 R
25	5579 B.A.C.	5	7 49·9	136 E	100 L	9 6·3	118 W	172 R

For East Longitude 77° 20′ and North Latitude 16° 25′.

			Disappearance.			Reappearance.		
1868.	Star's Name.	Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	13 35·4	92 E	48 L	14 56·5	133 W	169 L
3	29 Capricorni	5	11 54·4	33 E	43 L	13 20·9	77 W	104 R
4	38 Aquarii e^2	6	17 27·2	53 E	14 R	18 31·7	99 W	171 R
10	μ Ceti	4	11 9·3	67 E	141 L	12 8·2	110 W	34 R
12	1406 B.A.C.	7	12 29·9	66 E	138 L	13 23·5	99 W	24 R
12	Aldebaran	1	13 29·7	57 E	133 L	14 28·0	93 W	14 R
14	12599 Lalande	8	14 12·2	50 E	122 L	14 54·9	67 W	8 L
14	12650 Lalande	8	14 57·6	13 E	88 L	15 18·0	31 W	46 L
19	21487 Lalande	7½	6 51·3	151 E	77 L	7 31·7	110 W	177 L
22	xiii. 1016 Weisse's Bessel	8	9 25·8	48 E	25 R	9 56·7	16 W	90 R
23	ξ′ Libræ	6	6 56·9	119 E	67 L	8 17·2	83 W	147 R
25	5579 B.A.C.	5	8 15·6	136 E	93 L	9 27·1	121 W	178 R

For East Longitude 81° 10′ and North Latitude 16° 15′.

			Disappearance.			Reappearance.		
1868.	Star's Name.	Mag.	Local Mean Time.	Angle from North Point.	Angle from Vertex.	Local Mean Time.	Angle from North Point.	Angle from Vertex.
			h m	°	°	h m	°	°
Aug. 2	7043 B.A.C.	6½	14 0·7	100 E	51 L	15 14·0	140 W	159 L
3	29 Capricorni	5	12 18·4	39 E	39 L	13 50·3	86 W	122 R
4	38 Aquarii e^2	6	17 44·2	58 E	10 R	18 47·4	103 W	176 R
10	μ Ceti	4	11 24·0	70 E	144 L	12 24·3	113 W	37 R
12	1406 B.A.C.	7	12 43·8	69 E	142 L	13 39·5	101 W	25 R
12	Aldebaran	1	13 44·8	62 E	139 L	14 46·1	99 W	19 R
14	12599 Lalande	8	14 25·2	55 E	127 L	15 11·6	72 W	4 L
14	12650 Lalande	8	15 9·1	23 E	99 L	15 38·4	41 W	36 L
19	21487 Lalande	7½	7 6·0	148 E	74 L	7 46·6	108 W	179 L
22	xiii. 1016 Weisse's Bessel	8	9 40·8	50 E	23 R	10 13·5	20 W	94 R
23	ξ′ Libræ	6	7 20·3	118 E	61 L	8 37·6	84 W	150 R
25	5579 B.A.C.	5	8 41·8	137 E	88 L	9 47·7	125 W	176 L

Variations for one Degree of East Longitude, to obtain the times and points of contact in the neighbourhood of the three abovementioned Geographical Positions.

			For Disappearance.			For Reappearance.		
1868.	Star's Name.	Mag.	Time.	N.P. Angle.	Ver. Angle.	Time.	N.P. Angle.	Ver. Angle.
			m	°	°	m	°	°
Aug. 2	7043 B.A.C.	6½	+6·7	1·8 E	0·3 L	+4·7	1·8 W	2·6 R
3	29 Capricorni	5	+6·3	1·5 E	1·2 R	+7·8	2·2 W	5·2 R
4	38 Aquarii e^2	6	+4·5	1·3 E	0·9 L	+4·2	1·0 W	1·3 R
10	μ Ceti	4	+3·8	0·7 E	0·9 L	+4·2	0·9 W	0·7 R
12	1406 B.A.C.	7	+3·6	0·8 E	1·1 L	+4·1	0·8 W	0·5 R
12	Aldebaran	1	+3·9	1·3 E	1·6 L	+4·7	1·5 W	1·2 R
14	12599 Lalande	8	+3·3	1·2 E	1·6 L	+4·5	1·4 W	1·1 R
14	12650 Lalande	8	+2·4	3·6 E	3·9 L	+5·7	3·7 W	3·4 R
19	21487 Lalande	7½	+3·9	0·7 W	0·6 R	+3·9	0·3 E	0·5 L
22	xiii. 1016 Weisse's Bessel	8	+4·0	0·6 E	0·5 L	+4·4	0·9 W	0·9 R
23	ξ′ Libræ	6	+6·1	0·5 W	1·8 R	+5·4	0·1 W	0·8 R
25	5579 B.A.C.	5	+6·8	0·2 E	1·6 R	+5·4	0·8 W	1·6 R

A Catalogue of Spectra of Red Stars. By Father A. Secchi.

In a letter addressed to Admiral Manners, President of the Society, Father Secchi writes:—

"I send you, according to my last letter, a part of the Catalogue of Red Stars, examined with the spectroscope. Its construction has been improved by using only cylindrical lenses for the eyepiece, which has been made by M. Merz, and works admirably well. You will see that there is a new type of stars (the fourth) which is described in my Memoir in the *Soc. Italiana*, plate ii. fig. 7. I have already found several of that kind, so that it deserves to be characterised as a particular type. This classification is very curious indeed. I am, however, surprised to see some zones always at the same places; so that there is a great cosmical law which is about to come forth; but, for the present, we must wait until the review of all the stars has been accomplished. You see, however, that the red stars make quite a family by themselves, which is very distinct.

"I have examined (yesterday) the spectrum of Brorsen's Comet, although it was a little hazy and low. I have found it discontinuous, with a very bright and large zone in the green, and two narrower, but bright, also in the yellow and red, and a sufficiently strong zone in the blue. I hope to be able to send a drawing of it, but I must wait for better sky.

"*Rome, April* 23, 1868."

A Catalogue of Spectra of Red Stars.

The Numbers are those of the Catalogue of M. Schejellerup, published in the *Astr. Nach.*, and in Mr. Chambers' *Astronomy*. The position is his own, without further correction. In explanation of the description, I say that 1st type is *Sirius* or *α Lyræ;* 2d type of yellow stars is *Pollux* and the Sun; the 3d type is *α Orionis, α Herculis;* the fourth type is *Lal.* H. C. No. 12561, described in my memoir printed in the *Soc. Italiana*. In a second communication I will give the rest, since some want verification, although they have been observed. The indication *figured* is relative to the figures (coloured) which are at the Observatory. I have used the word *column* to indicate the large divisions in shape of pillars, which is characteristic to the third type in *α Herculis,* &c.

No. of Schej.	R.A.	Decl.	Mag.	Description and Colour (Sp. = Spectrum.)
	h m	° ′		
11	1 20·6	−33 17	6	Rose; sp. discontinuous, with zones.
12	1 23·4	+ 2 9	v. 8	Pale red; nothing particular.
16	1 59·0	+ 0 46	var.	Red; very weak.
17	2 8·1	+24 24	var.	Very rich yellow in the spectrum.
19 α Ceti	2 12·3	− 3 37	var.	In the max. of 3d mag. This star now has a sp. like α Orionis and β Pegasi, but with sharper lines, and resolved in more black field. Very fine object.
Algol	2 59·8	+40 27	v. 4	Type of α Lyræ even in the minimum.

No. of Schej.	R.A. h m	Decl. ° ′	Mag.	Description and Colour (Sp. = Spectrum.)
23	2 34·8	+31 50	neb.	Weak sp. with zones.
26	3 9·4	− 6 14	7	Yellow; sp. continuous.
33	4 13·7	−6 3	7.7	Sp. cont.; near it is another ✱ with zones.
34	4 14·2	+20 29	6	Pale red; sp. striated, but without zones.
36	4 20·6	+ 9 51	7½	Yellow orange; sp. with light zones.
38	4 26·7	−11 5	6.7	Yellow red; sp. striated, without zones.
39 Tauri	4 27·9	+16 13	1	Very red colour, and its spectrum shows not only lines, but even traces of zone, and columns. It was not so last year when the star was not so red. In the green are the four characteristic lines of α Orionis.
41	4 36·7	+67 55	6½	A superb object: a spectrum of the 4th type, divided in three columns, yellow, green, blue; figured.
43	4 42·7	+28 17	8	Pale red; sp. with 3 zones, as the preceding one; 4th type.
44	4 44·6	+14 1	5	Magnificent object; it is completely resolvable in columns and lines, like α Orionis.
45	4 46·5	+ 2 15	5½	Pale rose; lines very distinct, without columns.
46	4 48·2	+ 7 33	7	Pale; lines of the 3d type.
48	4 51·4	7 55	var.	Yellow golden; uniform sp.
49	4 53 ?	−15 1	var.	Spectrum uniform.
50	4 54·6	+ 0 31	6	Spectrum uniform.
51	4 58·2	+ 0 59	6½	Vivid red; sp. made of three bundles of zones; red and yellow very vivid; green very large; violet; figured.
54	5 10·4	+39 11	7	Weak, with lines; feeble.
58	5 22·6	− 1 12	5	Gold yellow, deep; strong magnesium line; spectrum almost uniform in the rest; type of the yellow stars.
59	5 24·1	+18 29	5½	Magnificent object, exactly like α Orionis; completely resolvable into lines; it is α Orionis in miniature; orange red.
60	5 29·3	10 57	7½	Spectrum with bands in the green.
63	5 35	+ 2 18	7.7	Small; nothing particular.
66 α Orionis	5 47·6	+ 7 23	1 var.	This star is more red this year than the last; the spectrum is divided into columns, but the striæ do not correspond in the red with the shades of the columns. The lines of the hydrogen are very visible. In the green the lines are very distinct. A new figure made, which agrees with that of the preceding years.
67	5 49·6	+45 55	5	Gold yellow; very fine star; the spectrum is completely resolvable, like *o* Ceti; splendid object.

No. of Schej.	R.A.	Decl.	Mag.	Description and Colour (Sp. = Spectrum.)
	h m	° '		
78	6 26·9	+38 33	6½	Star described in the *Mem. della Soc. Italiana.* This makes the 4th type, which consists in 3 large coloured zones of double extent of those of the 3d type. Magnesium very strong; vivid yellow, green, and blue; very curious thing!
83	6 49·9	70 56	6	Yellow; sp. uniform.
85	6 56·2	−27 44	3½	Yellow type; very fine striæ, with magnificent red, and strong black line in the green (magnesium).
87	6 58·9	22 55	var.	Small; nothing interesting.
89	7 1·5	−11 43	7½	Spectrum of the 4th type, but the middle black zone is narrower.
90	7 6·5	+59 10	7	Yellow; nothing particular.
91	7 7·2	+22 12	7·3	*Rufa;* weak; nothing singular.
96	7 34·6	+29 33	5	Yellow; sp. fine lines.
107	8 18·1	−37 50	6	Too low; nothing particular.
117	8 48·7	+20 23	var.	Small; nothing particular.
119	9 1·9	−25 17	4½	Gold yellow; strong line *b*, and vestiges of zones.
120	9 2·2	+31 32	6	Perfectly of the type of *α* Orionis, but in the interval of the columns the spaces are perfectly black, so that it gave a most discontinuous spectrum; very curious. In the green it is resolvable.
123	9 40·1	+12 5	var.	Small; sp. discontinuous, but very difficult.
Nobis.	9 16·7	−21 42	6½	Very fine yellow type of *α* Orionis; very neat, although small.
124	9 44·6	−22 22	6½	Type 4th, but the blue is very weak, so that there remain only the yellow, the red, and the green, separated by a very black interval.
127	10 4·0	− 7 44	6	Orange red; vestiges of weak zones. It is preceded by one of the 1st type.
128	10 5·8	−34 38	7	With very large zones and very neat; one very large in the green; it seems of the 4th type.
132	10 30 7	−12 39		Of the 4th type, very neat and luminous; it has two bright zones in the yellow, a very fine green and weak blue, separated by intervals. Figured. Colour, orange yellow.
136	10 44·8	−20 30	6½	4th type of spectrum, but reduced to the yellow and green; the rest is too weak.
137	10 52·6	−15 36	6	Clear red; type of *α* Orionis; well striated, but weak zones.
138	10 53·7	−17 34	8	Small, and nothing interesting.
141	11 10·9	33 52	4½	Gold yellow; the spectrum is like Capella, with fine lines; the lines F and *b* are very neat.

No. of Schej.	R.A.	Decl.	Mag.	Description and Colour (Sp. = Spectrum.)
	h m	° ′		
152	12 38·5	+46 13	5½	A most beautiful object; the spectrum is exactly of the fourth type. The luminous zones are exceedingly vivid, and make a curious contrast with the black interruptions. There are some very strong vivid zones in the yellow and in the blue. Figured. Very singular, indeed. The colour is a vivid ruby red.

On the Variability of η Argûs and Surrounding Nebula.
By F. Abbott, Esq.

The communications on the variability of η *Argûs* and the surrounding Nebula, which I had the honour of submitting to the Society, have led to the expectation of some continued observations on the light and character of both these objects.

The singularity of the nebulous portion of this region has but recently been made a subject for systematic examination, and but for the observations and beautiful monograph of Sir John Herschel, the peculiarities attached to it might have remained unknown for a long time to come.

In 1677 the star η was recorded by Halley as of the 4th magnitude. Its maximum was first noted by Burchell in 1827, it being then of the 1st magnitude; and on the 30th March, 1863, it was found for the first time reduced to the 6th magnitude. Independent, however, of the variability of the star itself, there is a much more singular property belonging to the surrounding Nebula, the particular features of which I now purpose to describe.

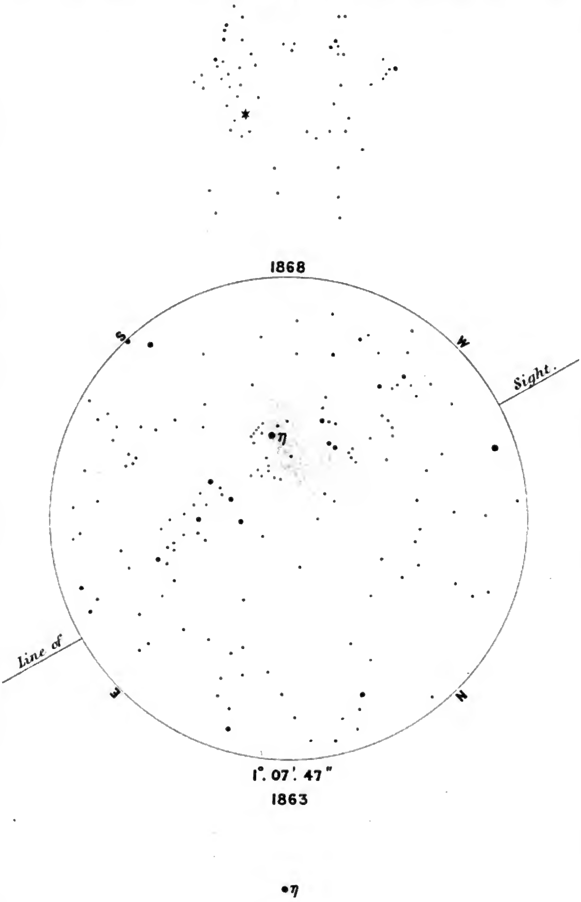
The mutability of the Nebula will be best made apparent by the accompanying drawing (see Plate), which will at once show the different forms of the dark space, and the relative position of η *Argûs* to it, from 1834–7 to 1868.

It must not be considered, however, that the position and character here given are the only ones in which the object has appeared; a system of photographs only would be the means of assisting materially the recognition of a principle of irregularity pervading the whole structure.

The missing portion of the nebulous matter, as compared with the Cape monograph, may be thought by some to be owing to the want of a larger optical power, but when the same instruments have been used throughout, this objection as to variability must fail to have any weight. The principal instrument used is a 5-feet Equatoreal by Dallmeyer. The building being situated in a garden, the view of a small portion of the circumpolar stars is intercepted by fruit-trees: to make good this want, a 5-feet portable refractor by Varley is used in the open air, so that the

η ARGUS AS SITUATED TO THE DARK SPACE, VARIABILITY OF THE SURROUNDING NEBULÆ, WITH THE MAGNITUDE AND POSITION OF ACCOMPANYING STARS.

1834-7.



FROM THE YEAR 1834 TO FEBRUARY 13TH, 1868.
TAKEN AT INTERVALS.

object has been watched and noted throughout its entire revolutions round the Pole.

The eye-pieces in general use, and found most suitable for this purpose, are a Comet one of 28, an Orthoscopic of 45, and an Annular Micrometer of about the same power. A more powerful instrument would, no doubt, at any one observation, alter the apparent features of the Nebula, and render manifest changes of a somewhat different character to those here described. To witness these effects I wait the arrival of the Melbourne telescope, when I hope to have the opportunity of more correctly verifying these statements.

The investigation of the fluctuations connected with the object η *Argûs* appears not to require such refined and delicate observations as were bestowed on Herschel's sub-nebulous region near the trapezone in *Orion*, by the late Professor Bond and Earl of Rosse; nor are such powerful instruments necessary.

Take, for instance, the position of the star η, as given by Sir J. Herschel at the Cape of Good Hope, and note its position again when in the darker space, as confirmed by E. B. Powell, Esq., at Madras, and now for the third time compare its situation, removed from the dark space altogether to quite a different portion of the Nebula, and it will appear clear that the optical means employed have been ample, notwithstanding Mr. Powell was at first inclined to think that the fluctuations were only apparent, and owing to the inferiority of his instrument.

The beautiful, soft, white light given out by the nebulous matter about η *Argûs* appears to be produced, either from the increased magnitude of the stars, or the displacement of some of the nebulous mass, or probably from both, for in the former case it is difficult to say (only from its position) which is η *Argûs*, and which is not, there being so great a similarity in its size and that of some of the accompanying stars. On a clear, fine night, the object gives out fully twice as much light as that of the Great Nebula—Nebicula Major, and about three times as much as Nebicula Minor, irrespective of size. In the twilight it appears as soon as a star of the second or third magnitude, the light being white and more diffuse, very like a small white woolly cloud on a blue sky, seen in Sunlight.

At present there appears to be no further diminution in the magnitude of the star below the 6th. Being in Melbourne on the night of the 25th March, 1865, which was a very fine one, and happening to look towards η *Argûs*, I fancied that the star appeared as a distinct point in the Nebula. I immediately proceeded to the Observatory, Mr. Ellery, with his accustomed kindness, allowing me to take possession of the Equatoreal; and on examining the object, found the colour of the small accompanying stars to be the same as before described, and, with the comparative eye-piece, considered the star to be 5·5. It was about this time that Mr. Tebbutt, of New South Wales, forwarded the result of his observations to the Society, giving the star as

5·5. This appearance, however, must be considered only transitory, for many times since that period the star has not reached more than the 6th magnitude, and may be so estimated at present.

The accompanying drawing was made with an inverting eyepiece, and taken 75° East of the Meridian, to prevent the unpleasantness of taking it near the zenith. If, therefore, the line of sight is brought to correspond with the South of the Cape Monograph, the position of both drawings will be made approximately to agree at the time they were taken.

Private Observatory, Hobart Town, Tasmania,
February 29, 1868.

Questions relative to the Original Inventor of the Achromatic Telescope. By A. D. Wackerbarth, Director of the Observatory of Upsala.

The invention of the Achromatic Telescope is one of such immense importance, that all facts and all persons in any way connected with its history assume a character of the most lively interest to those engaged in the cultivation of physical or astronomical science; one naturally desires to know as much as possible about them. Now we find in Grant's *History of Physical Astronomy*, p. 353, and in Hutton's *Mathematical Dictionary* (edit. 1796), vol. i. p. 26, as also in Barlow's *Optics* (*Encyclop. Metrop.* vol. iii. p. 408), that the man who really first invented this beautiful instrument was Chester More Hall, Esq., of More Hall, in the county of Essex, who not only discovered the secret of achromatism, but even constructed several achromatic telescopes as early as 1733. The two first of these writers quote, as the source of their information, the *Gentleman's Magazine* for 1790, part ii. p. 890. Sir John Herschel, in his noble essay on "Light" (*Encyclop. Metrop.* vol. iv. p. 411), calls Mr. Hall "a gentleman of Worcestershire," not Essex. I have in vain searched a map of Essex for this gentleman's residence, More Hall, and I have also searched the descriptions, both of Essex and Worcestershire, in the *Beauties of England and Wales*, as the collectors for that voluminous work generally give some biographical account of the worthies connected with the places they describe; but I have searched in vain, as I do not find that they mention any such place as More Hall in either of the above-named counties. The *Gentleman's Magazine* is not accessible to me here (at Upsala). One circumstance that renders Mr. Hall and his telescopes especially interesting is that, according to both Hutton's and Grant's citations from the *Gentleman's Magazine*, Mr. Hall, "about 1733, completed several achromatic telescopes (though he did not give them this name) *that bore an aperture of more than* 2½ *inches, though the focal length did not exceed* 20 *inches*, one of which is now [*i.e.* 1790] in the possession of the Rev. Mr. Smith, of Charlotte Street, Rathbone Place." It appears, then, that Mr. Hall's lenses must have been of a very good quality, for the length of his telescopes was only eight times their aperture, whereas an instrument by Dollond, preserved in this Observatory, with an aperture of four inches, has a length of ten feet, or thirty times the aperture; and even on the scale of Steinheil's telescopes (probably the most perfect yet constructed) an aperture of $2\frac{1}{2}$ inches ordinarily requires a focal length of thirty inches, or twelve times the aperture, that is, half as much again as Mr. Hall's. The length of instruments, even of the Herschel-Gauss construction, executed by Steinheil, is said to be ten times the aperture.

Mr. Hall's custom was, to have his lenses ground by ordinary workmen, but he himself put the finishing hand to the work, bringing up the surfaces to the exact curvature requisite "to correct not only the different refrangibility of rays, but also the aberration arising from the spherical figure of the lenses," so that both chromatic and spherical aberration were eliminated. It seems almost unaccountable that an invention so brilliant and so ably carried out should have fallen, and that in so short a time as thirty years, into oblivion, especially as Mr. Hall does not appear to have made any secret of it. For "old Mr. Bass, who at that time lived in Bridewell precinct, was one of those working opticians [namely, who ground lenses for Mr. Hall], from whom Mr. Hall's invention was obtained." As the invention was obtained (it is not said by whom) from Mr. Bass, it is clear that Mr. Hall must have communicated it to Mr. Bass, and he probably thought that this would be sufficient to perpetuate it, for, as he "was a gentleman of property, who did not look for any pecuniary advantages from his discovery," he no doubt supposed that, in communicating it to an artificer and tradesman, he had done sufficient to insure for ever to the public the benefit of it; but unfortunately, for his own fame, he made no legal publication of it. Who the persons were who opposed Dollond's claim to a patent, I know not, though no doubt the minutes of the trial in Westminster Hall before Lord Mansfield would inform us; but, as they produced on that occasion one of Mr. Hall's instruments as evidence of the art being already known, I take for granted that they were tradesmen, opticians, who had received the knowledge of Mr. Hall's invention from Mr. Bass. Hutton's citation from the *Gentleman's Magazine* concluded thus: "That Mr. Ayscough, optician on Ludgate Hill, was in possession of one of Mr. Hall's achromatic telescopes in 1754, is a fact, which at this time [1790] will not be disputed." This, I take it, was the instrument which Mr. Barlow says was on sale that year. But both Sir John Herschel and Mr. Barlow state (*locis citatis*) that, when they wrote, *i.e.* A.D. 1827, some of Mr. Hall's telescopes were still in existence. I conceive it therefore to be highly probable that some of them are even now to be found, and if so, it would be in the highest degree interesting if any one having access to one of them would give an accurate and detailed description of it. Mr. Hall was evidently a man of no ordinary capacity and perseverance, and all that can be learned about him would doubtless be instructive and interesting. It would be desirable to know what sort of lenses he used, of what kind of glass, how they were disposed, and whether their number was two or more, what sort of eye-pieces the instrument was furnished with, &c., &c. Such information cannot be too highly prized.

Uppsala, April 16, 1868.

(*From the* " *Gentleman's Magazine,*" 1790, part ii. p. 890.)

"The writer of an Introduction to some Letters lately published, on the Improvement of Ship-building, seems to have been misled in saying, 'that great discovery in optics, the achromatic glasses, was entirely owing to three or four ingenious men assembling at a public-house in Spitalfields, to amuse themselves in friendly conversation upon mathematical and mechanical subjects.'

"As the invention has been claimed by M. Euler, M. Klinginstierna, and some other foreigners, we ought, for the honour of England, to assert our right, and give the merit of the discovery to whom it is due; and therefore, without further preface, I shall inform the author of the above quotation that the inventor was Chester More Hall, Esq., of More Hall, in Essex, who, about 1729, as appears by his papers, considering the different humours of the eye, imagined they were placed so as to correct the different refrangibility of light. He then conceived that if he could find substances having such properties as he supposed these humours might possess, he should be enabled to construct an object-glass that would show objects colourless. After many experiments he had the good fortune to find these properties in two different sorts of glass; and by forming lenses made with such glass, and making them disperse the rays of light in contrary directions, he succeeded. About 1733 he completed several achromatic object-glasses (though he did not give them this name) that bore an aperture of more than 2½ inches, though the focal length did not exceed 20 inches; one of which is now in the possession of the Rev. Mr. Smith, of Charlotte Street, Rathbone Place. This glass has been examined by several gentlemen of eminence and scientific abilities, and found to possess the properties of the present achromatic glasses.

"Mr. Hall used to employ the working opticians to grind his lenses: at the same time he furnished them with the radii of the surface, not only to correct the different refrangibility of rays, but also the aberration arising from the spherical figures of lenses. Old Mr. Bass, who at that time lived in Bridewell precinct, was one of those working opticians, from whom Mr. Hall's invention seems to have been obtained.

"In the trial at Westminster Hall about the patent for making achromatic telescopes, Mr. Hall was allowed to be the inventor; but Lord Mansfield observed, that 'it was not the person who locked up his invention in his *scrutoire* that ought to profit by a patent for such invention, but he who brought it forth for the benefit of the public.' This, perhaps, might be said with some degree of justice, as Mr. Hall was a gentleman of property, and did not look to any pecuniary advantage from his discovery; and, consequently, it is very probable that he might not have an intention to make it generally known at that time.

"That Mr. Ayscough, optician on Ludgate Hill, was in possession of one of Mr. Hall's achromatic telescopes in 1754, is a fact which at this time will not be disputed.

"VERITAS."

Remarks on the Name of the Star ξ Scorpii (= Fl. 51 *Libræ*).

By A. Brothers, Esq.

In a note to the reprint of my list of Binary Stars, which appeared in the last Number of the Society's proceedings, Mr. Chambers calls attention to the fact that I, at the suggestion of the late Rev. W. R. Dawes, had designated the star 51 *Libræ* "ξ *Scorpii*," as also did Smyth, "but in retaining the appellation "51 *Libræ*" he (Mr. Chambers) "had followed the better supported usage."

The reason for the proposed alteration will be found in the following quotation from a letter received from Mr. Dawes in Sept. 1866, in which he says, "I should really be glad if you would assist in restoring this star to *Scorpio*, from which it was taken by a mere blunder of Flamsteed's, as is generally acknowledged. Why then do not astronomers generally follow the course of that most accurate of all star-catalogue and star-map authors, Argelander, and erase this star from *Libra* (which has already *three other* ξ's, and restore it to *Scorpio*, which, without this, has no ξ at all? The best way, perhaps, to write the name would be 'ξ *Scorpii* (= Fl. 51 *Libræ*).' To continue perpetuating Flamsteed's acknowledged blunder seems to me nothing less than absurd." This, to me, was quite sufficient to authorise the change suggested, and I had no hesitation in following the advice of one so thoroughly competent to give it. Mr. Dawes named the star in his own Catalogue in the same manner.

A copy of the list of binaries, as it is printed in Mr. Chambers' book, was forwarded to Mr. Dawes, who on the 21st March, 1867, wrote to me as follows:—"I confess that I cannot help feeling much annoyed that this excellent opportunity of giving your support to the rectification of the blunder about ξ *Scorpii* should have been thrown away; or rather, in fact, that, *contrary to your own conviction*, you should have been made to appear a *supporter of the blunder*." The words in italics are so marked by Mr. Dawes.

It will be seen by reference to the Catalogue as published by the Manchester Literary and Philosophical Society, and also in the *Astronomical Register*, that the star is named as Mr. Dawes proposed, and it will, I think, be admitted that the opinion expressed by Mr. Dawes ought to have been respected, unless any good reason could be found for the alteration made by Mr. Chambers.

The reason assigned by Mr. Chambers for publishing a second edition of my list (which is not the *Catalogue*), with the addition of a few objects of the doubtful class, is, that the R.A.'s and Decs. are not brought down to any uniform epoch. The difference of ten years, more or less, appeared to me of no consequence, as the stars could be found just as well whether the places were given for 1860 or 1870; and the places of the whole of the objects excepting those taken from Smyth's *Cycle*, are given for 1860, but the remainder I reduced to 1865; in the latter case the reduction was a matter of necessity, but in the former it was not.

Mr. Chambers remarks, "As there were other defects in it (the list), which it is not worth while to particularise," and refers to his re-computation and re-writing the list as a matter of necessity, owing to the errors he had detected in it. I shall be obliged if Mr. Chambers will point out these errors; for beyond one or two printer's errors I am not aware of the existence of any. If the Catalogue, as published in full, is the one referred to, I know of only one error, and that is the substitution of the name of one observer for another, a matter of very trivial consequence.

In the compilation of a work of this kind very much must depend on the judgment of the compiler. It may be thought by some that γ *Andromedæ* (not γ^2) and one or two other objects ought to have been omitted, but it will be seen by reference to the introduction to the Catalogue, that I have given reasons for inserting them.

On this subject Mr. Dawes wrote to me 13th Oct. 1867: "As to the way in which you have accomplished your rather arduous task, so entirely self-imposed, I assure you that I think you have done it in excellent style, and provided a very useful companion to the observatory for all double-star observers."

As to the *necessity* for such alterations as are introduced by Mr. Chambers, it will be seen by reference to my Catalogue that some of Mr. Dawes's measures are given as late as Dec. 1866 (1866·99), with many others by different observers in the same year; and I am not aware that any information to which Mr. Chambers could refer has been published since the date named, and which could justify him in altering the figures in the list which I prepared for his book.

To quote again from one of Mr. Dawes' letters, in which he says: "It is not by any means easy in some cases to determine, with anything like certainty, what are truly *binary* stars." If Mr. Chambers will go through all the published results and produce a Catalogue differing in any important particulars from the one I have already published, I have no doubt it will be found useful; at the same time I do not think much fresh material to work upon will be found, considering that a large proportion of the most valuable part of my Catalogue was supplied by the observers specially for my work.

Remarks on the Stellar Longitudes assigned by Ptolemy. By W. W. Drayson, Capt. and Major Royal Artillery, Prof. of Surveying, &c. R. M. Academy, Woolwich.

The Star Catalogue of Ptolemy being the earliest of which we have any record, has always possessed great interest to astronomers. It has been most ably arranged by the late Mr. Bailey in vol. xiii. of the *Memoirs.*

An examination of the longitudes of various stars in Ptolemy's Catalogue has revealed a singular fact, which we will express in the words of Mr. Baily. "That Ptolemy was an observer, is I think manifest from his recorded observations of the planets, as well as from other evidence which his incomparable treatise affords. Nevertheless it must be admitted that the positions of the stars in his Catalogue will not agree with the precise epoch that he has stated, but that the longitudes must be increased at least 1°, the latitudes remaining the same." The fact of the longitude being in almost every case 1° too little in the above Catalogue is so well known, that no further reference need be made to this portion of the subject.

In the *Nautical Almanac* for 1822, the longitudes of nine stars are given. By comparing these longitudes with that assigned by Ptolemy we find the following differences in degrees and minutes:—

	°	′
α Arietis	24	24
Aldebaran	24	32
Pollux	23	59
Regulus	24	45
Spica Virginis	24	35
Antares	25	30
α Aquilæ	25	19
Fomalhaut	24	15
α Pegasi	24	14

The Catalogue of Ptolemy is reduced to the first year of the reign of Antoninus, which corresponds to A.D. 138. Hence the interval between 138 and 1815 is 1677 years.

Taking the precession in longitude to be 50″·2 annually, we ought to find for 1677 years a difference of only about 23° 23′ in the longitudes, instead of nearly 24½°.

The conclusion that appears to have been very generally arrived at is, that Ptolemy did not observe, but merely copied from his predecessors; this conclusion the Author thinks is not sound.

As far as the Author is aware, no satisfactory explanation has hitherto been given of the reason for all Ptolemy's longitudes being too little, thus whilst we cannot but admire the ingenuity of this ancient astronomer's method for determining longitudes, we yet perceive his results erroneous and in one direction.

The instruments used by Ptolemy and his contemporaries seem to have been of three kinds; only one of which will be referred to, viz. the Astrolabe, for taking the distances in longitude between the Sun and Moon, and the Moon and a star.

This instrument consisted of two rings fixed at right angles to each other, one in the plane of the ecliptic, the other in that of the solstitial colure. Two other rings were fixed to the instrument so as to form circles of celestial longitude, and turned about an axis, therefore coincident with the poles of the ecliptic.

When an observation was made for longitude, one of the moveable circles was directed to the Sun or Moon, having been first fixed to that degree of the ecliptic circle which expressed the known longitude of the Sun, thus the zero of the graduations was made to agree with the vernal equinox in the heavens.

Then the other moveable circle of longitude was directed to the second body, and the arc of the ecliptic between the zero and moveable circle gave the star's longitude. Considering that Ptolemy had no clocks, we think no more ingenious method than this could be adopted for determining longitudes of stars.

Having now considered the instrument in use, we will next speak of the method which must have been adopted.

In the first place, during *the evening* and earlier portions of the night was the most suitable time for using this instrument, and not after sunrise or during daylight, because the stars were not then visible. This fact being established it would follow that the order of the observations must have been made very much in the following manner:—

The Sun's longitude having been calculated for the day and hour of observation, the first movable circle was directed towards the Sun when near sunset, and thus the zero of longitudes would be fixed. A star not being visible as long as the Sun was above the horizon, the Moon would necessarily be made use of, and her longitude could readily be obtained by measuring the arc on the ecliptic between the Moon and the Sun. Hence the most suitable time for using the astrolabe would be during the first quarter of the Moon.

In the same manner that we determined the Moon's longitude by this instrument, so could we determine the longitude of a star. For by keeping one circle fixed on the Moon, whose motion in longitude was very fairly known by Ptolemy, the other circle being directed to the star, the *difference* in these two bodies' longitudes would be obtained, and hence the longitude of the star could be fixed.

We can now take a simple example of this method.

Suppose the Sun at the instant of observation or of fixing the instrument, to be at the vernal equinox, the Moon on the ecliptic and in quadrature. Hence the Moon's longitude would be 90°, and the angular distance between the Sun and Moon 90° on the sphere. The Moon would be on the meridian at 6 P.M., and would set at midnight. Suppose a star on the ecliptic and 90° from the Moon, this star's longitude would have been obtained by Ptolemy by obtaining its distance from the Moon at any convenient time of night, and finding the arc on the ecliptic marked by his two circles. Having fixed the longitude of any star, this star could be made use of instead of the Sun for obtaining the position in the heavens of the vernal equinox. Thus it is evident that the first start must be best made from fixing the instrument to obtain the zero of longitudes by *the Sun*. Next obtain the Moon's longitude from the Sun and then that of a star.

The Moon might be made use of for fixing the zero of longitudes, but from the irregularities of her movements, it is probable that the Sun was most generally used.

In either case, however, a very considerable error in all longitudes would arise in consequence of Ptolemy not being aware of one item used in Astronomy.

Taking the latitude of Alexandria (where it is supposed Ptolemy made his observations), to be 31°, the Moon when having its greatest north declination, would be only about $2\frac{1}{2}°$ from the zenith. Referring to the example already given, the Moon would then have been within $2\frac{1}{2}°$ of the zenith and the Sun on the horizon. Ptolemy was unacquainted with the effect of refraction, and therefore would assign to the Moon at such a time a longitude or distance from the Sun too little by the amount of the Sun's refraction, which near the horizon would be 30′. The effect of refraction would be to bring the Moon and Sun *nearer* together, for the Moon being near the zenith, the Sun would be brought nearer thereto by refraction, and hence the Moon's assigned longitude would be less than it ought to be by 30′.

If after the Moon's longitude had been thus determined by the astrolabe, a star near the eastern horizon were selected, or if Ptolemy waited until a star reached his meridian whilst the Moon had approached the western horizon, another error of nearly 30′, and in the same direction, would be added to the first, and thus from refraction alone, the star would be given 1° too little longitude.

Although the method here dealt with is that probably used by Ptolemy, it may be supposed an extreme case, and one giving the greatest amount of error; it is so, but it may be borne in mind that in nearly every case refraction brings celestial bodies nearer together, and *never* causes them to appear further apart than they really are. In fact, when the Sun was on the horizon and the Moon at the zenith, their distance would be lessened by 34′, whilst if the Moon were on the horizon and a star at the zenith, their angular distance would be lessened by an additional 34′, making a total of 1° 8′ error in longitude of the star, which 1° 8′ would be too little. Hence a star whose true longitude was 180° would be assigned only 178° 52′.

It seems probable that Ptolemy would select the period of either the vernal or autumnal equinox as the period for determining the longitude of some star, also that he would, to ensure the Moon's longitude being as slightly changed as possible, select the time when the Sun was near the horizon, and thus these conditions, being those best adapted for the working of his astrolabe, would yet give the greatest error from refraction.

To account for all the errors in the Catalogue of Ptolemy is of course impossible, many of these are undoubtedly due to errors of observation and to imperfect instruments. The Author merely endeavours to point out in this paper how it is possible, if not probable, that with such an instrument as the astrolabe an observer unacquainted with refraction would be in error about 1° in all his longitudes, and that this 1° would be shown by omitting that amount from his assigned longitudes, which would therefore in every case be too little, as is the case in Ptolemy's Catalogue.

On a New Driving-Clock for Equatoreals.

By Thos. Cooke, Esq.

One of the great essentials of modern astronomical observation — second only in importance to the perfection of the object-glass or mirror employed—is a perfectly steady, firm, and uniform motion of the instrument under the varying resisting forces to which it is subjected.

By such a motion the fixed micrometer-wire and the (apparently) moving celestial body remain at absolute rest with regard to each other for a large interval of time.

One of the most satisfactory attempts to attain this end was made by the great Fraunhofer in the driving-clock attached to the refractor at Poulkowa. In this arrangement the motion was regulated by the friction of centrifugal balls against the interior of a conical box, the rate of motion being determined by raising or depressing the pivot of the conical pendulum; each change in the position of the pivot changing the degree of friction.

In a modified form this system has for many years been adopted in this country, but I have never been thoroughly satisfied as to its perfect uniformity: indeed, it is very difficult to imagine that a perfectly uniform rotatory motion can ever be attained by such a regulator, whenever changing resistances have to be overcome.

It was, doubtless, this consideration which induced the lamented Professor Bond to adopt his "Spring Governor," in which the regulator took the form of an oscillating pendulum, the intermittent movement being transferred into a uniform one—first, by means of the torsion of a spring fixed lengthwise on the axis of one of the wheels; and secondly, by means of an air-fan. Although the regulation of the spring governor was correct in theory, it failed in practice, owing to the delicate nature of the principle, as soon as varying resistances had to be overcome. In both the systems referred to the motive power was a weight.

In a third arrangement adopted by the Astronomer Royal, water is used as a motive power and regulator; the resultant motion being controlled, in addition, first by a conical pendulum, and secondly, by Siemens' chronometric arrangement.

My attention has lately been specially directed to these various arrangements, as it has become necessary to construct a driving-clock for the Great Refractor. The defects of the two former systems were so strong to my mind, that the arrangement now brought before the notice of the Society was devised to replace them. The regulator adopted in this driving-clock is the vibrating pendulum, because, amongst the means at the mechanician's command for obtaining perfect time-keeping, there is none other by which the same degree of accuracy can be obtained. The difficulty in this construction is the conversion of the jerking or intermittent motion produced by such pendulums into a uniform rotatory motion, which can be available *with little or no disturbing influence on the pendulum itself*, when the machine is subject to varying frictions and forces to be overcome in driving large equatoreals. This was the difficulty proposed to be met by Bond's Spring Governor. It is met in the new one by the principles and mechanical arrangements described below.

1. The pendulum is a half-second one, with a heavy bob, adjusted by sliding the suspension through a fixed slit. It is drawn up and let down by a lever and screw, the acting length of the pendulum being thus regulated. The head of this screw is made large and grooved, and holds an endless cord, by which the observer can at once regulate the speed.

2. The scape-wheel is a double one, each wheel having four teeth; the pallets are round steel pins, producing nearly a dead beat, and work between the two scape-wheels. The teeth of one wheel strike one pallet; the teeth of the other wheel on the other pallet. A small amount of recoil is purposely given. The wheel makes one revolution in eight vibrations or in four seconds.

3. The arrangement of the wheels represents something like

the letter U. At the upper end of one branch is the scape-wheel. At the upper end of the other branch is an air-fan. The large driving-wheel and barrel are situated at the bottom or bend. All the wheels are geared together in one continuous train, which consists of eight wheels and as many pinions. The scape-wheel and the two following wheels have an intermittent motion. All the others have a continuous and uniform one.

4. The change from one motion to the other is made at the third wheel, which, instead of having its pivot at the end of the arbor where the wheel is fixed—fixed to the frame like the others—is suspended from above by a long arm having a small motion on a pin fixed to the frame, the pivot at the other end of the arbor is fixed to the frame as the others are, but its hole and its pivot are arranged so as to permit a very small horizontal angular motion round them, as a centre, without interfering with the action of the gearing of the wheel itself.

5. The wheel with its suspended pivot has nothing to do in changing the relative speed of the wheel and pinion into which it is geared, but it acts as a kind of '*remontoire.*' Supposing, for instance, the wheel below it, into which it is geared, is stationary; a force applied horizontally at the pivot would cause this remontoire wheel to *roll* on the one below it, and to give motion to the wheel and scape-wheel above it.

6. The suspending piece which carries the movable pivot and remontoire wheel has projecting from it, inwardly, a branch, which, while the clock is in motion, presses against a spring fixed horizontally and pivoted to the frame; the other end of which is made slender, and imparts a gentle pressure on a smooth wheel rapidly revolving, in order that a small amount of friction will have a great regulating power.

7. If the weight is applied to the clock when the pendulum is not vibrating, the force of the weight tends to give motion to the wheel below the remontoire one, and to all the wheels up to the air-fan; the spring is gently forced against the friction-wheel, and then prevents any further motion of the train. The spring in this position pushes the movable pivot outwards, and makes the remontoire wheel tend to move the one above it, and through it the scape-wheel.

8. If the weight is applied to the clock, and the pendulum is made to vibrate, the moment it begins to move, the scape-wheel moves its quantity for a beat; the remontoire wheel, by the very small force outwardly caused by the reaction of the break-spring, relaxes its pressure against the friction-wheel, and sets at liberty the train of the clock.

9. The spring is now driven back to the break-wheel, but before it can produce more than the necessary friction to keep the train in uniform motion, another beat of the clock again releases it. The repetition of these actions produces a series of impulses on the break-wheel of such a force and nature as to keep the train freely governed by the pendulum.

10. The small motion of the remontoire wheel pivot to and fro is equal only to about $\frac{1}{100}$th of an inch.

The above description will give a general idea of the arrangement adopted; it may be mentioned that instead of friction produced by a spring, the remontoire wheel may be made to act on an air-fan inclosed in a box, through the openings in the periphery of which, more or less air will be allowed to pass according to the force of the train.

The uniform rotatory motion obtained by this clock as far as experiments can be made by applying widely different weights, and comparing the times with a chronometer, is perfectly satisfactory.

A clock constructed on the same principle, connected with, and giving motion to, a cylinder, will, it is presumed, make an excellent chronograph.

Southampton Street, Strand,
May 13, 1868.

On a persistent Marking on Jupiter. By J. Browning, Esq.

The first in order of date of the two drawings of *Jupiter* which I have now the honour to submit to the Society, was made on Sept. 12, 1867, at 10·15 P.M., with the Barnes $10\frac{1}{4}$-in. reflector, power 200. The second drawing was made with my own $12\frac{1}{4}$-in. reflector, same power, on Dec. 22, 1867, at 5.30 P.M. On both these drawings a dark belt, to the N. of the bright equatoreal cloud-belt, will be seen to have a rather uniformly corrugated appearance on the lower or northern edge.

This corrugation I have represented on the diagram I have here, which is enlarged from one of the drawings. During the interval between taking the two drawings, I frequently saw the marking I have described, whenever the air was sufficiently steady to allow me to use powers above 100.

I am well aware that markings on *Jupiter* have been observed to remain almost unchanged for some months at a time. But my reason for directing attention to this particular marking is that I have noticed, that in Mr. De La Rue's well-known beautiful drawing of *Jupiter* taken in October 1856, a marking greatly resembling this is shown in exactly the same position.* I am therefore, inclined to think that this mark may possibly indicate the conformation of the surface of the planet, or at least some peculiar condition of this portion of the planet's atmosphere.

---

* The mark can only be recognised in Mr. De La Rue's own engraving from his drawing, it is not shown in any of the numerous woodcuts which have been copied from it.

Observations of the Zodiacal Light. By Major Tennant.

Jan. 23. Lat. about 17° 30′, N.—Conspicuous but ill-defined vertex about half way between 4 and α Tauri and 3° N. of line.

Jan. 27.—Not so bright and more confused. Lat. 12° N. The bright light has its vertex near μ *Piscium*, and it is more faintly traceable to ξ^1 *Ceti*.

Jan. 28.—Moonlight. Lat. 11° 30′. Traceable notwithstanding young Moon to ο *Piscium*.

Jan. 29.—*Venus* seen easily at half an hour after noon. *Jupiter* invisible.

Feb. 10, *Madras*.—Moonlight compelled observations too early in evening, but traced Zodiacal Light to near δ *Arietis*.

On Saturday, February 23, the vertex of the Zodiacal light was not visible, the light merged in that of the borders of the Milky Way. I have never seen any appearance of angularity in the light. I have watched it from sunset at intervals till 9 P.M., and after the glow of sunset was gone have always found the shape a portion of a long ellipse, or parabola, ill defined at the outlines, and fading away, and with a marked condensation of light towards the axis and horizon. I will endeavour to estimate the position of the axis in future, but it is very difficult to place the lower end among the stars. The brightness of *Venus* much interferes with observation of that part till it has set.

Calcutta, March 1, 1868.

Occultation of γ *Tauri*, 28 *March*, 1868. By John Joynson, Esq.

Lens $3\frac{1}{2}$-in., Power 60.

	h m s	
Disappearance	9 2 48·5	G.M.T.
Reappearance	9 58 20·4	,,

At the disappearance the dark limb of the Moon was clearly seen, and in both cases the time was deemed exact.

	h m s	
Long.	0 12 7	W.
Lat.	53° 28′ 24″	N.

Waterloo, near Liverpool,
April 3, 1868.

Eclipses of Jupiter's Satellites, observed at Windsor, New South Wales. By John Tebbutt, Jun. Esq.

The accompanying observations of Eclipses of *Jupiter's* Satellites were made with a refractor of 3¼ inches aperture and 4 feet focal length. A magnifying power of about 90 was employed in the observations of July 20th, 24th, and 25th, 1867; but, in all the other observations a power of 120 was used. The times were noted by means of an eight-day half-seconds chronometer of Parkinson and Frodsham's construction. The last column contains a comparison of the observed times with those in the *Nautical Almanac*, the longitude employed for the comparison being $10^{h}\ 3^{m}\ 15^{s}{\cdot}7$ E. Signals by electric telegraph exchanged between Mr. Smalley and myself, give $1^{m}\ 30^{s}{\cdot}04$ as the longitude of my Observatory *west* of the Sydney Observatory. The longitude of the latter, finally deduced by the Rev. W. Scott from comparisons of the Sydney Moon culminations with corresponding observations at Greenwich in 1860 and 1861, and at the Cape of Good Hope in 1859, is $10^{h}\ 4^{m}\ 45^{s}{\cdot}7$ E. of Greenwich: (see the vol. of *Sydney Astronomical and Meteorological Observations* for 1861). $10^{h}\ 4^{m}\ 45^{s}{\cdot}7$ *minus* $1^{m}\ 30^{s}{\cdot}0$ gives $10^{h}\ 3^{m}\ 15^{s}{\cdot}7$, therefore, as the longitude of my Observatory *east* of Greenwich. I may mention that twenty-six transits of the Moon's first limb and four of the second observed here in 1866, and compared with the *Nautical Almanac*, give $10^{h}\ 3^{m}\ 19^{s}{\cdot}1$ E., and eighteen of the first limb in 1867, $10^{h}\ 3^{m}\ 23^{s}{\cdot}1$ E. as the approximate longitude. These culminations were observed by means of a Transit of 2·1 inches aperture, mounted on a substantial pier, and the chronometer above mentioned.

The following correction should be made in my observations of η *Argûs*, published in page 83 of the 26th vol. of the *R. A. S. Notices*:—

In the 12th line from the bottom, *for* 1818, *read* 3818.

Eclipses of Jupiter's Satellites, observed at Windsor, New South Wales, in the years 1866 *and* 1867.

Date.	Satellite.	Phase.	Windsor M.T.	App. Error of Naut. Alm.
1866.			h m s	m s
June 4	I.	Disappearance	11 27 50·5	−0 3·9
28	II.	ditto	9 36 14·6	−0 26·4
28	III.	ditto	11 22 22·8	+0 33·5
July 6	I.	ditto	8 1 25·5	+0 35·9
23	II.	Reappearance	9 22 49·6	+0 7·1
Aug. 17	II.	ditto	6 25 39·9	+0 54·4
24	II.	ditto	9 2 6·4	+0 18·5
Sept. 6	I.	ditto	9 3 59·2	−0 16·6
8	III.	ditto	6 47 19·2	+3 9·0

Date.	Satellite.	Phase.	Windsor M.T.	App. Error Naut. Alm.
1866.			h m s	m s
Sept. 13	I.	Reappearance	10 59 6·9	−0 3·0
15	III.	Disappearance	7 23 0·5	+1 46·1
15	III.	Reappearance	10 48 8·2	+3 32·5
18	II.	ditto	6 9 28·9	+0 3·2
22	I.	ditto	7 23 22·8	−0 7·9
25	II.	ditto	8 46 23·8	−0 3·4
Oct. 15	I.	ditto	7 38 33·0	−0 13·4
Nov. 14	I.	ditto	9 49 2·6	−0 43·8
Dec. 3	III.	ditto	7 3 49·9	+0 23·5
1867.				
July 20	III.	Disappearance	11 38 0·1	+0 22·0
24	II.	ditto	8 54 4·0	−0 6·8
25	I.	ditto	9 36 42·9	+0 4·1
27	III.	ditto	15 36 57·6	+1 42·7
31	II.	ditto	11 28 6·8	+0 30·0
Aug. 1	I.	ditto	11 30 55·3	+0 24·8
10	I.	ditto	7 54 21·6	+0 23·8
17	I.	ditto	9 49 20·4	+0 15·5
30	IV.	Reappearance	6 19 32·6	+0 7·3
Sept. 18	I.	ditto	8 43 14·2	−0 1·2
Oct. 7	III.	ditto	11 17 29·2	+1 34·5
11	I.	ditto	8 59 42·8	−1 6·4
18	I.	ditto	10 54 14·3	+0 1·4
19	IV.	Disappearance	8 32 9·0	+6 40·2
19	IV.	Reappearance	12 52 19·7	+0 39·3
21	II.	ditto	8 1 33·9	−0 53·5
Nov. 5	IV.	ditto	7 7 52·9	−2 50·2
19	I.	ditto	7 35 0·9	−0 2·2
19	III.	Disappearance	8 4 23·8	+1 32·6
22	II.	Reappearance	7 46 49·7	−1 40·2
Dec. 12	I.	ditto	7 51 15·6	−0 26·0

Remarks.

1866.
June 4. Good observation; definition very good.

28. Full Moon present. The disappearance of the II. Satellite was observed in clear sky; that of the III. Satellite through a thin cirrus cloud.

July 6. Planet ill defined and boiling. Final disappearance noted; the satellite had disappeared and reappeared a few seconds earlier.

23. Definition very good, but time probably rather late, owing to proximity of satellite to planet's limb.

Aug. 17. Excellent definition.

24. Night beautifully clear, but Moon near her opposition, and not far from planet. Good observation.

Sept. 6. Thin clouds flying across planet, but images bright and well defined at reappearance.

1866.

Sept. 8. Night calm, and beautifully clear.

13. Calm, and sky beautifully clear. Definition very good.

15. Sky very clear. Telescope vibrated slightly at disappearance, but definition pretty good. Excellent definition at reappearance.

18. Observation during twilight, the Sun's upper limb having disappeared below the horizon just 23·3 minutes previously. Sky beautifully clear, and definition good. Moon in first quarter, and not far from planet.

22. Definition pretty good.

25. Good definition.

Oct. 15. Night beautifully clear, and definition very good.

Nov. 14. Imperfect observation through cloud. Planet rather low and near Moon.

Dec. 3. Satellite first perceived in the twilight at time noted; the other three satellites had shortly before become visible.

1867.

July 20. Very good definition, but Moon about 3° distant from planet.

24. Planet low, but definition good. I thought I could just perceive a faint trace of the satellite again for a moment six seconds after the time noted.

25. Excellent definition.

27. Sky hazy; bad observation.

31. Sky hazy; bad definition.

Aug. 1. Clear sky; good definition.

10. Planet boiling; observation unsatisfactory.

17. Sky clear about planet, but Moon present. Definition pretty good, but images rather tremulous.

30. Sky cloudless, but twilight had scarcely disappeared. Planet low and boiling.

Sept. 18. Clear calm night.

Oct. 7. Good observation. Definition pretty good, but Moon present.

11. Moon present, and sky overspread with thin cloud.

18. Excellent definition, but observation probably a second or two late.

19. Definition unusually good at disappearance, and immersion very gradual. Images not so well defined at reappearance, and somewhat tremulous. Observation, however, pretty good.

21. Sky clear, and definition pretty good.

Nov. 5. Unsatisfactory. At the time noted the satellite was plainly distinguishable, and almost in contact with another satellite. The fourth satellite came out so nearly in a visual line with the other as to be hardly distinguishable from it for some time.

19. Excellent definition in both cases, but the disappearance was very gradual.

22. Sky very hazy.

Dec. 12. Sky very clear. Definition good, but images rather tremulous.

Windsor, New South Wales,
February 28, 1868.

Further Notice of the Lunar Crater Linné.

By the Rev. T. W. Webb.

Since the communication of my previous remarks on this object, I have fortunately obtained an observation which I hope may be thought worthy of the honour of being laid before the Society.

1868, March 30. 9⅓-inch silvered glass speculum; definition generally unsteady, with a tendency to double images, but at intervals quiet and clear. Terminator through the "pass" between *Caucasus* and the *Apennines:* the ring of *Cassini* coming into sight.

Linné was speedily made out with 450 as a minute black crater elongated N. and S. with a very narrow wall; the brightest part of the whole object being the rise of the *glacis* on the W. side. 212 had barely power enough; but at times the little black crater was quite certain. Single lens about 275, certain and clear at times. 450 again; sometimes very plain, at others blurred. I see plainly the traces of the white cloud, and that *Linné* (the minute crater) is central. The crater is barely half the size of *Linné* A. Afterwards it was extremely distinct with 212, and could be glimpsed with 170. The commencement of the white cloud was very evident with 65.

I am confident that, under the present illumination, there is nothing visible on the site of *Linné* but the minute crater, and the traces of the cloud.

The occasional clearness of definition was proved by my first sight of a very difficult object, obligingly mentioned to me by Mr. Knott, the minute crater on *Posidonius* γ; which I could see with 450, and afterwards 212 showed me at times even its very narrow ring.

On the two following nights the black crater of *Linné* diminished, as the white cloud increased, in visibility: on neither occasion was the definition equal to that of the 30th.

Though the command of the object which I possessed on the 30th left no doubt whatever on my mind, it was with great pleasure that I received the following confirmation from Mr. With of Hereford, who had been observing the Moon on the same night:—

"Definition unsteady, but wonderfully sharp at times: a tendency to double image from atmospheric disturbance. Aperture 12⅛-inches silvered glass; focus 6½ feet; power 300 ±. During moments of steady vision the crater of *Linné seen* as a black spot surrounded by a narrow brilliant ring. Ring considerably brighter than the 'cloud.' Crater not round—elongated N. and S. Seen several times during a period of about 30 minutes."

The accurate eye and the extraordinary optical advantages employed in this latter observation induce me to hope that the Society will accept the verification as one of no ordinary value, especially as regards the elongated form. On the night in question I was under an impression that it had been so delineated by Mr. Huggins, but this I find was a mistake, and I am not aware that it has been so seen by any previous observer.

Hardwick Parsonage, April 13, 1868.

On the Lunar Crater Linné. By C. L. Prince, Esq.

I beg to communicate to the Society the following observations respecting the Lunar Crater *Linné:*—

1867, July 8th. With a power of 140 on my telescope of 6·8 inches aperture and 12 feet focal length, *Linné* presented a cloudy appearance only; but, with the power increased to 378, I could, by glimpses, distinguish the small black Crater.

July 9th. *Linné* appeared as a cloudy spot.

July 10th. The small black circular crater easily visible; but the definition was not good enough to enable me to trace the edge of external shallow one.

Aug. 8th. *Linné* merely a cloudy spot.

Nov. 3d. With a power of 288 I saw *Linné* to great advantage this evening, as a fairly defined crater, within which was an elevation, having a small circular crater on its summit. A thin line of shadow was visible within the western wall. The eastern wall was occasionally visible, but its elevation appeared very trifling.

1868, March 1st. I observed *Linné* very satisfactorily for about twenty minutes before the Moon was obscured by clouds. The shallow crater was distinctly visible on the western side, but not on the eastern. The western slope of the somewhat conical elevation had a very rugged surface and an overhanging crag near the top. It was brilliantly illuminated by the strong Sunlight to the very edge of the small crater, which was encircled by a ring of metallic lustre. I again observed that this little crater is both circular and deep; the interior shadow being very dark. The usual cloudiness was not seen, and the general colour of the *Mare* was maintained to the wall of the shallow crater.

On the following evening *Linné* was merely a cloudy spot.

May 1st. The Moon being nine days old, and *Linné* far removed from the terminator, I was not a little surprised to see the small crater beautifully distinct, about 7 P.M. It appeared, as heretofore, perfectly circular; its interior shadow as black as it was on March 1st, and in fine contrast with its bright edge. Its depth must be very remarkable, considering the elevation of the Sun on the ninth day of the Moon's age. Very little cloudiness was visible, and this gradually disappeared as I increased the magnifying power from 140 to 430. The atmosphere at 8 P.M. was so diaphanous that I was able to use rather high powers to great advantage. The ascent from the base of the central elevation to its summit is much shorter and more precipitate on the western than on the eastern side. The position and appearance of the small crater, given by Mr. Huggins, at page 296, vol. xxvii. of the *Notices*, appear to me very correct, had its diameter been a little larger.

Although the definition was unusually fine from 7 to nearly 9 P.M., on the 1st inst., yet at 10 P.M., in consequence of the wind having shifted suddenly to the eastward, it became so bad that the whole of *Linné* was at once converted by it into a confused, cloudy, white patch, without a trace of the crater being visible.

Various observations of my own and others now lead me to the belief that no physical change has taken place in any part of *Linné*, and that the different aspects which it has presented to different observers must be ascribed to the ever-varying conditions of our own atmosphere.

Observatory, Uckfield, May 6, 1868.

Note on the Lunar Crater Linné. By Mr. Birt.

Linné.—The observations made on the 30th March last, which have come under my notice, are so interesting that I am induced to submit a synopsis of them with a view of soliciting further attention to this now remarkable object.

The white spot was observed as such by Messrs. Key, Webb, Buffham, and Crossley.

Mr. Crossley remarks that the obscuration round the crater appeared circular, and somewhat dished, but badly defined at the edges.

The large shallow crater was observed by Capt. Noble (*Monthly Notices*, vol. xxviii. p. 187), and by Mr. Huggins, who describes the western wall as much higher than the other. (*Report of the Proceedings of the R. A. S. in Astronomical Register*, No. 65, p. 103.)

The small crater was seen by the Rev. H. C. Key, who speaks of it as being situated on the summit of a gradually rising mound; the Rev. T. W. Webb, who saw it elongated N. and S., black inside, sharp narrow ring. Mr. Webb adds, that his observation was confirmed by Mr. With. Mr. Crossley's observations will be found in the *Monthly Notices*, vol. xxxviii. p. 187. It was also seen by Mr. Huggins; see *Astronomical Register*, as above. Mr. Buffham saw a round bright spot towards the W. side, about $\frac{1}{4}$ (or a little more) of the diameter of the light circle, with a kind of gray shading near the middle of the white spots E. of the bright spot as shown by his sketch. A correspondent (T. P.) of the *Register* says that *Linné* was seen of a small crater form with a central black spot surrounded by a thin bright ring.

By the period of similar phase, viz. $59^d\ 1^h\ 28^m$, after which interval the terminator will pass over nearly the same portion of the Moon's surface; the variation of the Sun's declination at the Moon slightly changing the angle which the terminator makes with the meridian—*Linné* will be almost similarly situated with regard to the terminator, on May 28, 1868, a slight alteration in the Sun's altitude being produced.

An interval of 442 days 23 hours will again bring the terminator very near *Linné*, about an hour earlier than the time of the observations of March 30. This will occur in 1869, on the evening of June 16, when the angle of illumination will be nearly similar; the Sun in the mean time having passed its greatest S. declination, and approached the Moon's equator; its declination at the Moon never exceeds 1° 32′ 9″. The quantities stand as under :—

1868	March 30	$\odot - ☊ = 217^\circ\ 13'{\cdot}5$	S dec. approaching Solstice
	May 28	$\odot - ☊ = 277\ \ 38{\cdot}1$	S dec. past Solstice
1869	June 16	$\odot - ☊ = 315\ \ 54{\cdot}1$	S dec. approaching Equinox.

On the last two mentioned days, other circumstances being equal, *Linné* may be expected to present similar phenomena to those noticed on March 30, so far as illuminating angle is concerned. Libration will, however, affect the visual angle, and should good observations be obtained, it may be worth while to compute the effect produced by the variation of the two angles.

Cynthia Villa Observatory, Walthamstow,
1868, *May* 5.

Ephemeris of Brorsen's Comet. By Dr. C. Bruhns.

Perihelion passage 1868, April 18·4393.

1868. 0h Berlin T.	α	δ	Log. r	Log. Δ
	h m s	° ′		
May 10	5 58 51	+ 44 20·8	9·8701	9·9830
11	6 7 16	45 3·9		
12	15 55	45 44·8		
13	24 48	46 23·3		
14	33 54	46 59·3	9·8963	9·9721
15	43 14	47 32·6		
16	52 46	48 3·0		
17	7 2 29	48 30·4		
18	12 24	48 54·6	9·9224	9·9643
19	22 28	49 15·8		
20	32 40	49 33·5		
21	42 59	49 47·7		
22	53 22	49 58·5	9·9480	9·9600

1868. 0h Berlin T.	α h	α m	α s	δ °	δ ′	Log. r	Log. Δ
May 23	8	3	49	50	5·6		
24		14	17	50	9·3		
25		24	44	50	9·3		
26		35	9	50	5·9	9·9728	9·9593
27		45	29	49	58·9		
28		55	43	49	48·6		
29	9	5	48	49	35·0		
30		15	44	49	18·2	9·9966	9·9622
31		25	29	48	58·3		
June 1		35	2	48	35·6		
2		44	22	48	10·2		
3		53	28	47	42·3	0·0194	9·9688
4	10	2	19	47	12·0		
5		10	54	46	39·5		
6		19	15	46	5·0		
7		27	20	45	28·8	0·0411	9·9786
8		35	9	44	50·9		
9		42	43	44	11·5		
10		50	2	43	30·9		
11	10	57	5	+ 42	49·2	0·0617	9·9913
12	11	3	54	42	6·5		
13		10	29	41	23·1		
14		16	51	40	38·9		
15		22	59	39	54·1	0·0813	0·0067
16		28	54	39	8·8		
17		34	57	38	23·2		
18		40	8	37	37·3		
19		45	27	36	51·4	0·0999	0·0237
20		50	36	36	5·5		
21		55	35	35	19·6		
22	12	0	24	34	33·9		
23		5	3	33	48·3	0·1177	0·0424
24		9	34	33	2·9		
25		13	56	32	17·9		
26		18	10	31	33·2		
27		22	17	30	48·8	0·1346	0·0622
28		26	17	30	4·8		
29		30	9	29	21·2		
30		33	55	28	38·1		
July 1		37	34	27	55·4	0·1506	0·0829
2		41	7	27	13·2		
3		44	35	26	31·6		
4		47	57	25	50·5		
5		51	14	25	10·0	0·1660	0·1040

1868. 0^h Berlin T.	α	δ	Log. r	Log. Δ
	h m s	° ′		
July 6	54 26	24 30·0		
7	57 34	23 50·5		
8	13 0 37	23 11·6		
9	3 37	22 33·2	0·1806	0·1252
10	6 33	21 55·4		
11	9 24	21 18·2		
12	12 12	20 41·5		
13	14 58	20 5·4	0·1947	0·1466
14	17 40	19 29·8		
15	20 19	18 54·8		
16	22 55	18 20·3		
17	25 28	17 46·4	0·2081	0·1677
18	27 58	17 13·0		
19	30 26	16 40·1		
20	32 51	16 7·8		
21	35 14	15 36·0	0·2209	0·1887
22	37 35	15 4·6		
23	39 54	14 33·8		
24	42 11	14 3·4		
July 25	13 44 25	+ 13 33·6	0·2333	0·2092
26	46 38	13 4·2		
27	48 49	12 35·3		
28	50 58	12 6·9		
29	53 6	11 39·0	0·2451	0·2293
30	55 12	11 11·4		
31	57 17	10 44·3		
Aug. 1	59 21	10 17·6		
2	14 1 23	9 51·5	0·2565	0·2489
3	3 24	9 25·7		
4	5 23	9 0·2		
5	7 21	8 35·2		
6	9 19	8 10·6	0·2675	0·2679
7	11 15	7 46·4		
8	13 10	7 22·5		
9	15 4	6 59·0		
10	16 57	6 35·9	0·2780	0·2865
11	18 49	6 13·1		
12	20 40	5 50·7		
13	22 30	5 28·6		
14	24 20	5 6·8	0·2882	0·3044

Instruments for Sale.

A Refractor, of 8 inches aperture and 10 feet focal length, mounted equatoreally by Cooke and Sons, with circles finely divided in silver; driving clock, &c., complete. The object-glass, by Alvan Clarke, is a very fine one, and was formerly in the possession of the late Rev. W. R. Dawes. The instrument is at present mounted in the Observatory of Mr. Huggins, at Upper Tulse Hill, to whom application is to be made.

A 7-foot Equatoreal, by Simms. Aperture 4·9 inches; declinated circle, 18 inches; hour circle, 15 inches; also an 18-inch transit circle. Apply to the Rev. J. Slatter, Streath Vicarage, Berks.

ERRATUM.

P. 6, line 12, *dele* previously.

CONTENTS.

Page
Fellow Elected 193
Occultations visible in August, 1868, by Mr. Chary ... ... ib.
A Catalogue of Spectra of Red Stars, by Father A. Secchi 196
On the Variability of η *Argûs* and surrounding Nebula, by Mr. Abbott 200
Questions relative to the original Inventor of the Achromatic Telescope, by Mr. Wackerbarth 202
Remarks on the name of the star ξ *Scorpii* (= Fl. 51 *Libræ*), by Mr. Brothers 205
Remarks on the Stellar Longitudes assigned by Ptolemy, by Capt. Drayson 207
On a New Driving-Clock for Equatoreals, by Mr. Cooke... 210
On a persistent Marking on Jupiter, by Mr. Browning 213
Observations of the Zodiacal Light, by Major Tennant 214
Occultation of γ *Tauri*, 28 March, 1868, by Mr. Joynson ... ... ib.
Eclipses of *Jupiter's* Satellites, observed at Windsor, New South Wales, by Mr. Tebbutt 215
On the Lunar Crater *Linné*, by the Rev. T. W. Webb 218
" " " by Mr. Prince 219
" " " by Mr. Birt 220
Ephemeris of Brorsen's Comet, by Dr. Bruhns 221
Instruments for Sale 224
Erratum ... ... ib.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *June* 12, 1868. No. 8.

Admiral Manners, President, in the Chair.

C. H. H. Cheyne, Esq., 1 Dean's Yard, Westminster;
Henry Wm. Hollis, Esq., Ormston Manor, Derby;
Wm. Rossiter, Esq., Collingwood Street; and
Robert Wm. Skiffington Lutwidge, Esq., Barrister-at-Law,

were balloted for and duly elected Fellows of the Society.

On the Variable Star η Argûs and its Surrounding Nebula.
By Sir J. F. W. Herschel, Bart.

The changes recorded by Mr. Abbott, in his communications to this Society, published in vols. xxiv. and xxv. of the *Monthly Notices*, and more especially in the *Notice* which has just appeared (vol. xxviii. p. 200), are so very astonishing that it is high time the attention of every astronomer in the southern hemisphere provided with instruments at all competent to show, I will not say all the details—but—the brighter portions of the nebula, should be directed to its delineation, and to the relative situations of every star within 10′ or 15′ of the principal star. There is no phenomenon in nebulous or sidereal astronomy that has yet turned up, presenting anything like the interest of this, or calculated to raise so many and such momentous points for inquiry and speculation. The question here is not of minute variations in subordinate features, which may or may not be attributable to differences of optical power in the instruments used by different observers, as in the case of the nebula in *Orion* (the only one comparable to it in magnitude, complexity, and brightness), but of a total change of form and character—a complete subversion of all the greatest and most striking features—accompanied with an amount of relative movement between the star and the nebula, and of the brighter portions of the latter *inter se*, which reminds us more of the capricious changes of form and place in a cloud drifted by the wind than of anything heretofore witnessed in the sidereal heavens. In fact, not only as compared with the appearance of the nebula in 1834–7, which my delineations record, does Mr. Abbott's diagram of 1868 exhibit so astonishing a dissimilarity; but, when compared with the drawing given by himself at so recent a date as 1863 (vol. xxiv. p. 5), the difference is such that no one could possibly suppose the two representations referred to one and the same object.

η *Argûs* itself, though a variable star of the most extraordinary character, is nearly devoid of proper motion: the annual change due to this cause, in R.A. and N.P.D., as given in the Catalogue of the British Association, being only $-0^{\text{sec.}}\cdot001$ and $-0''\cdot09$, so that it is entirely owing to movements going on within the nebula itself that the change must be owing. But here comes the most astonishing part of the whole affair. The neighbourhood of η *Argûs* is thickly sown over with small stars. Of these, within the compass of a little more than a square degree, having η in the middle, I determined in 1834–7 the situations and apparent magnitudes of upwards of 1200; and, during all the course of my observations, never found reason to suspect the situations of any of these to be variable either *inter se* or with respect to η. Now Mr. Abbott's figure, as given in the recent Number of the *Monthly Notices*, shows this star accompanied by 150 stars of various magnitudes within a field of view (so I interpret the subscript figures 1° 07′ 47″) of 1° 8′; and of these I have not been able satisfactorily to identify any one individual with any one in my Catalogue.

To be quite satisfied on this point, I laid down upon his figure a set of lines corresponding to the meridians and parallels of my chart,* being guided in their direction by the letters N S and E W (which I presume to express the situations of the North and South, and East and West points of his field of view at the moment of delineation); in their distance from each other in P D. by the diameter 68′ of the circle, containing exactly 17 intervals of 4′, the distance between the parallels on my chart (4′ = 1000 micrometer parts), and in R.A. so as to correspond in due proportion to the intervals of $50^{\text{sec.}}$ of time between my meridians. This done, the places of Mr. Abbott's principal stars (within the limits of my chart) were read off as nearly as the small scale of the figure would allow, and are here set down — the magnitudes assigned being according to the best judgment I could form, from the size of the dots expressing them in the engraving, taking η itself as 6 mag. As regards the larger stars, this can hardly be very erroneous, though, as respects the smaller ones, no conclusion can be formed, since, though Mr. Abbott states the *focal lengths* (5 feet) of the telescopes he used, he nowhere mentions their apertures.

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* "Cape Observations," Plate ix.

Star's Mag.	Δ R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Microm. parts, each = 0″·004.	Star's Mag.	Δ.R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Micr. parts, each = 0″·004.
η = 6 m.	0	0	8 m.	−42	−1600
6 m.	−165	−5950	7.8 m.	+30	+5200
9 m.	−147	−1750	7.8 m.	+45	+6000
9 m.	−120	−1400	8 m.	+77	− 450
8 m.	− 55	− 900	8 m.	+80	+ 400
8 m.	− 45	−1850	8 m.	+87	−1250

The following are the principal stars within the limits of Mr. Abbott's field of view, as given in my Catalogue*:—

Star's Letter and Mag.	Δ.R.A. from η in Seconds of Time.	Δ N.P.D. from η in Microm. parts = 0″·004.	Star's Letter and Mag.	Δ.R.A. from η in Seconds of Time.	Δ.N.P.D. from η in Micr. parts = 0″·004.
η = 2 m.	0	0	λ = 8 m.	+ 37·8	−4143
ω = 8 m.	−148·0	−1332	δ = 8 m.	+ 66·7	−5486
O = 7 m.	− 65·5	−2023	σ = 9 m.	+ 78·9	+5014
C = 8 m.	− 51·6	+ 539	κ = 8 m.	+155·9	−1726
U = 7 m.	− 38·5	+4627	W = 6 m.	+158·3	+2782
D′ = 8 m.	− 29·1	+ 860	γ = 7 m.	+178·9	+3441
D = 8 m.	− 28·8	+ 798			

The utter disagreement of these two lists of the principal stars is apparent, and renders it unnecessary to go into a comparison of those of smaller magnitude.

Conceiving it possible, however, that the letters N, S, E, W, may be misplaced in Mr. Abbott's diagram, or that the nature of the inversion of his eye-piece may have been, by myself, misapprehended, I laid down, on the same scale, a miniature of my chart on thin paper, with the meridians and parallels, placing on it in their proper positions all the stars in this latter list. Then, oiling the paper so as to render it transparent, it was laid down on Mr. Abbott's diagram, the two stars η in each being brought to coincidence. Turning then the oiled chart round on the diagram, no situation could be found to bring about any tolerable coincidence of the stars in the one and the other. The same result was obtained when the oiled chart was reversed (laid *face downwards*) on the diagram, and turned round in the same way.

What then are we to conclude? Not only the nebulous masses would appear to have drifted far away from their situations in 1835, but the stars of the whole region over an area of nearly two-thirds of a square degree, including stars of the 6th, 7th, and 8th magnitudes, to have also either assumed new configurations *inter se*, or to have bodily fled away and given place to a new set!

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[*] "Cape Observations," pp. 42, *et seq.*

Again, within a circle of 6′ radius round η, in Mr. Abbott's diagram occur 19 minute stars. In my chart, within a circle of the same radius, are laid down 57, of which two are of the 8th, four of the 10th, and two of the 11th magnitudes, but among all these not one can be satisfactorily identified with any of his. The best approach in general appearance is that of the line of five very small stars in close vicinity to η and to the immediate south of it, which may be considered as somewhat to resemble the crooked line of stars G, (ε), (ζ), (η), (θ), in my chart. But *these* are quite otherwise situated with respect to η, and their general direction makes an angle of 70° with the parallel (from *s p* to *n f*).

Another very puzzling feature in Mr. Abbott's description is the brightness he ascribes to the nebula, which he states to "give out fully twice as much light as that of the Nubecula major," "irrespective of size." How far the diminution of light in η from the 2d to the 6th magnitude may affect the visibility to the naked eye of the nebula in a dark night, I cannot pretend to say; but on no occasion do I remember to have perceived with the naked eye any nebulosity about it even in a dark night, and assuredly not in a twilight, such as just to allow stars of 2.3 mag. to become visible. *Such* a twilight effectually obliterates both the Nubeculæ, which, however, are both — the N. major especially — very conspicuous objects in a dark night.

It is much to be wished that some southern observer furnished with an equatoreally mounted telescope would *without further delay* set to work in earnest, and map down the stars visible within this most interesting area, down at least to the 10th or 11th magnitude. Possibly I may have done Mr. Abbott injustice by assuming that his diagram is intended to convey any *delineation* at all of the stellar contents of his field of view; or anything beyond the forms of the nebulous masses, as existing *among* scattered stars. But the question once raised is of the last importance and *must* be settled; especially in regard to what he himself says, *Monthly Notices*, vol. xxv. p. 4, as to the "increased number" [since 1837] "of brilliant isolated stars with a change in the position of η *Argûs*," as "the effect produced with a 5-foot achromatic;" in obvious reference to the *nebular hypothesis* of the formation of stars and planets by the condensation of nebulous matter. And this leads me to observe that, having taxed in vain my recollection as to the authorship of the passage which he there ascribes to me* on the subject of this theory, and not having succeeded in finding it in any of my published writings, I shall feel obliged to any friend who will refer me to the place where it occurs, as it certainly seems to convey a much more definite and decided view of the matter than I should *now* like to endorse.

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* "It will appear" . . . "that every succeeding state of nebulous matter is the result of the action of gravitation, and by such steps the successive condensation of it is brought to a planetary or stellar condition. Several instances are on record which connect the planetary with the stellar appearance. In those instances wherein the collection of nebulous matter was very extensive, subordinate centres of attraction could not fail to be established, around which the adjacent particles would arrange themselves, and thus the whole mass would in process of time be transformed into a determinate number of discrete bodies, which would ultimately assume the condition of a cluster of stars." — *Monthly Notices*, vol. xxv. p. 4.

Collingwood, June 8, 1868.

A determination of the Constant of Nutation from the observations in N.P.D. of Polaris, Cephei 51, *and δ Ursæ Minoris, made with the Transit Circle of the Royal Observatory, Greenwich*, 1851–1865. By E. J. Stone, Esq. (Abstract.)

The Transit Circle of the Royal Observatory, Greenwich, has been in regular use since the beginning of the year 1851, and the results, down to the year 1865 inclusive, are in the hands of astronomers. In the construction of the instrument no arrangements were provided for shifting the relative positions of the reading-microscopes, or the divisions under the microscopes, in any given position of the instrument. The same divisions are thus employed in the observation of a star for many years. This arrangement undoubtedly offers great advantages for the determination of a constant, like that of Nutation, where what we require is, that observations extending over many years should either be free from systematic error, or, which is quite as good for the present purpose, be affected only with constant errors. The division errors of the Greenwich Transit Circle were elaborately investigated in 1850 and again in 1857. The errors of the divisions under the microscopes, in the observations of the Nadir-point with the reflecting eye-piece, in the observations of *Polaris, Cephei* 51, and *δ Ursæ Minoris*, above and below pole, have also been separately investigated in 1857 and 1865.

The astronomical flexure of the telescope has been determined on the following occasions:—

Date.			Horizontal Flexure.
1850	Dec.	30	+0″·41
1851	Feb.	5	+0·88
1852	Dec.	23	+0·20
1857	Jan.	5	+0·46
1857	Jan.	21	+0·66
1860	Sept.	1	+0·67
1864	Sept.	7	+0·76

The mean value of the horizontal flexure = + 0″·58.

1867	April	25	−0″·34
1867	May	8	−0·31
1867	May	13	−0·37

Mean value of the horizontal flexure = − 0″·34.

In the autumn of 1865, the central cube of the transit-circle was pierced to allow of the adjustment of the wires of the collimating-telescopes on each other, without the necessity of first raising the transit-circle. In the operation of piercing the cube the state of strain of the instrument was so changed that the horizontal astronomical flexure of the instrument was found to be altered by nearly one second of arc. From the erection of the instrument to the time of piercing the cube, a discordance of a well-marked character had been observed between the nadir points, determined from observations with the reflecting eye-piece, and those resulting from observations of stars, north and south of the zenith, directly, and after reflexion at the surface of the quicksilver. With the change of sign in the flexure of the telescope, a change of sign in the law of the discordance R − D has also been shown by the observations of 1866 and 1867. If the discordances between the nadir-points arise from imperfect correction under the assumed law (= constant × sin Z D), a slight abrupt change in the resulting N.P D. of a star may be expected to take place with the piercing of the cube. Such a change would, to a very considerable extent, be destroyed by the method adopted in the Greenwich reductions of applying a correction to the final results for the discordance R − D. I have, however, thought it better, for my present purpose, to keep entirely free from the necessity of applying any empirical correction such as that for R − D, and have therefore terminated the investigation with the date of piercing the cube. As all the observations after September 1865 were made with the altered flexure, I have not been able to employ the observations of *Polaris* made in the year 1865: the annual group for this year would not be strictly comparable with preceding annual groups.

The observations made use of have been extracted from the N.P.D. ledgers printed in the volumes of *Greenwich Observations*, 1851 to 1865. Different division errors, values of assumed horizontal astronomical flexure, and nadir-points deduced from a combination of reflecting-eye-piece determinations with results obtained from observations of stars by reflexion, have been employed in the reduction of the results as extracted directly from the ledgers. As the nadir-points employed are mixed up with the adopted flexure and adopted division errors, I have thought it better to reduce all the observations to nadir-points determined with the reflecting-eye-piece alone. The following Tables give the data employed in the reductions of different years, the data adopted, and the corrections required to reduce the material to one uniform system.

Colatitude used	1851 to 1854	38° 31′ 21″·80
	1855 to 1860	22·00
	1861 to 1865	21·80
Adopted colatitude		38 31 21·80

Corrections for Division Errors + Effect of Astronomical Flexure, as used in the Reductions.

		1851 & 1852.	1853 to 1856.	1857.	1858 to 1864.	1865.
Nadir		+0″·86	+0″·63	+0″·76	+1″·02	+1″·20
Polaris		+0·69	+0·60	+1·07	+1·09	+1·14
Polaris	S.P.	+0·92	+0·84	+1·18	+1·40	+1·45
Cephei 51		+0·72	+0·63	+0·99	+0·99	+1·05
Cephei 51	S.P.	+0·79	+0·72	+0·92	+0·92	+0·96
δ Ursæ Minoris		+0·81	+0·71	+0·94	+0·94	+1·00
δ Ursæ Minoris	S.P.	+0·79	+0·72	+0·92	+0·92	+0·96

Corrections for Division Errors + Effect of Astronomical Flexure, adopted in this investigation.

Nadir = +0″·75
Polaris = +0·64
Polaris S.P. = +0·97
Cephei 51 = +0·73
Cephei 51 S.P. = +0·45
δ Ursæ Minoris = +0·64
δ Ursæ Minoris S.P. = +0·52

Numerical Corrections to the North Polar Distances of the Ledger Results.

		1851 & 1852.	1853 to 1856.	1857.	1858 to 1864.	1865.
Polaris		+0″·06	−0″·08	−0″·42	−0″·18	″
Polaris	S.P.	−0·16	−0·01	+0·20	+0·16	
Cephei 51		+0·12	−0·02	−0·25	+0·01	+0·13
Cephei 51	S.P.	+0·23	+0·39	+0·46	+0·20	+0·06
δ Ursæ Minoris		−0·06	−0·19	−0·29	−0·03	+0·09
δ Ursæ Minoris	S.P.	+0·16	+0·32	+0·39	+0·13	−0·01

The value of the nutation-constant employed in the reductions has been

9″·25 from 1851 to 1856 inclusive.
9″·224 from 1857 to 1865 ,,

The true value of this constant has been assumed

$$9''\cdot224 + x.$$

The following are the corrections for the effects of the precessional motion of the Earth's axis, which have been employed to reduce the mean N.P.D.'s for each year to the year 1858.

Year.	Polaris.	Cephei 51.	δ Ursæ Min.
	′ ″	″	″
1851	− 2 14·551	+ 18·839	− 11·792
1852	− 1 55·306	+ 16·281	− 10·025
1853	− 1 36·069	+ 13·678	− 8·284
1854	− 1 16·840	+ 11·031	− 6·570
1855	− 0 57·618	+ 8·339	− 4·884
1856	− 0 38·404	+ 5·603	− 3·228
1857	− 0 19·198	+ 2·824	− 1·600
1858	0·000	0·000	0·000
1859	+ 0 19·190	− 2·868	+ 1·572
1860	+ 0 38·372	− 5·780	+ 3·117
1861	+ 0 57·547	− 8·737	+ 4·634
1862	+ 1 16·713	− 11·738	+ 6·122
1863	+ 1 35·871	− 14·782	+ 7·581
1864	+ 1 55·021	− 17·871	+ 9·012
1865	+ 2 14·162	− 21·003	+ 10·415

Polaris.

Assumed mean N.P.D., Jan. 1, 1858,—

$$1^\circ\ 26'\ 51''{\cdot}222 + y.$$

Assumed proper motion in N.P.D. $= 0''{\cdot}00 + \delta p$.

The equations of condition for the yearly groups, are

Year.				*w*
		″		
1851	$y + 0{\cdot}7598\,x =$	$+ 0{\cdot}026$	$+ 7\,\delta p$	32·06
1852	$y + 0{\cdot}7443\,x =$	$- 0{\cdot}034$	$+ 6\,\delta p$	35·10
1853	$y + 0{\cdot}6324\,x =$	$- 0{\cdot}108$	$+ 5\,\delta p$	26·46
1854	$y + 0{\cdot}4591\,x =$	$- 0{\cdot}180$	$+ 4\,\delta p$	45·81
1855	$y + 0{\cdot}2174\,x =$	$- 0{\cdot}015$	$+ 3\,\delta p$	33·23
1856	$y - 0{\cdot}0203\,x =$	$- 0{\cdot}026$	$+ 2\,\delta p$	34·66
1857	$y - 0{\cdot}2739\,x =$	$- 0{\cdot}069$	$+ \delta p$	45·75
1858	$y - 0{\cdot}4946\,x =$	$+ 0{\cdot}109$		57·44
1859	$y - 0{\cdot}6650\,x =$	$+ 0{\cdot}092$	$- \delta p$	52·50
1860	$y - 0{\cdot}7495\,x =$	$+ 0{\cdot}082$	$- 2\,\delta p$	30·37
1861	$y - 0{\cdot}7573\,x =$	$- 0{\cdot}082$	$- 3\,\delta p$	43·01
1862	$y - 0{\cdot}6678\,x =$	$+ 0{\cdot}093$	$- 4\,\delta p$	27·99
1863	$y - 0{\cdot}5180\,x =$	$+ 0{\cdot}093$	$- 5\,\delta p$	34·25
1864	$y - 0{\cdot}2978\,x =$	$+ 0{\cdot}017$	$- 6\,\delta p$	38·17

Multiplying each equation by the corresponding value of *w*, and reducing the equations to two by the method of least squares, we have the following equations for the determination of y and x.

$$536\cdot80\,y - 84\cdot204\,x = +\,0''\cdot472 \quad + 211\,\delta p.$$
$$-84\cdot204\,y + 167\cdot257\,x = -\,14\cdot157 \quad + 913\,\delta p.$$

From which we deduce

$$x = -\,0''\cdot091 \quad + 6\cdot1\,\delta p$$

or Nutation constant $= 9''\cdot133 + 6\cdot1\,\delta p$.

Cephei 51.

Assumed mean N.P.D. Jan. 1, 1858,—

$$2^\circ\,44'\,59''\cdot8 + y.$$

Assumed proper motion in N.P.D. $= +\,0''\cdot08 + \delta c$.

The equations of condition for the yearly groups are

Year.			w.
1851	$y + 0\cdot413\,x = +\,0''\cdot538$	$+\,7\,\delta c$	3
1852	$y + 0\cdot074\,x = +\,0\cdot040$	$+\,6\,\delta c$	3
1853	$y - 0\cdot251\,x = +\,0\cdot090$	$+\,5\,\delta c$	3
1854	$y - 0\cdot563\,x = +\,0\cdot240$	$+\,4\,\delta c$	9
1855	$y - 0\cdot803\,x = +\,0\cdot470$	$+\,3\,\delta c$	5
1856	$y - 0\cdot948\,x = +\,0\cdot483$	$+\,2\,\delta c$	6
1857	$y - 0\cdot987\,x = +\,0\cdot464$	$+\,\delta c$	5
1858	$y - 0\cdot923\,x = +\,0\cdot472$		12
1859	$y - 0\cdot722\,x = +\,0\cdot430$	$-\,\delta c$	14
1860	$y - 0\cdot490\,x = +\,0\cdot156$	$-\,2\,\delta c$	8
1861	$y - 0\cdot166\,x = +\,0\cdot278$	$-\,3\,\delta c$	6
1862	$y + 0\cdot161\,x = +\,0\cdot296$	$-\,4\,\delta c$	3
1863	$y + 0\cdot480\,x = +\,0\cdot102$	$-\,5\,\delta c$	12
1864	$y + 0\cdot737\,x = +\,0\cdot076$	$-\,6\,\delta c$	11
1865	$y + 0\cdot918\,x = +\,0\cdot238$	$-\,7\,\delta c$	5

Multiplying each equation by the corresponding value of w, and reducing the equations to two by the method of least squares, we have for the determination of x and y the following equations,—

$$105\,y - 26\cdot157\,x = +\,30''\cdot470 \quad - 99\,\delta c$$
$$-26\cdot157\,y + 49\cdot778\,x = -\,16\cdot085 \quad - 133\,\delta c$$

From which we find

$$x = -0''{\cdot}196 - 3{\cdot}6\,\delta c$$

or Nutation constant $= 9''{\cdot}028 - 3{\cdot}6\,\delta c$.

δ Ursæ Minoris.

Assumed mean N.P.D. Jan. 1, 1858,—

$$3^\circ\ 23'\ 55''{\cdot}00 + y.$$

Assumed proper motion $-\ 0''{\cdot}03 + \delta m$.

The equations of condition for the yearly groups are

Year.	″		w.
1851	$y - 0{\cdot}4546\,x = 1{\cdot}507$	$+ 7\,\delta m$	9
1852	$y - 0{\cdot}1306\,x = 1{\cdot}526$	$+ 6\,\delta m$	9
1853	$y + 0{\cdot}1980\,x = 1{\cdot}530$	$+ 5\,\delta m$	4
1854	$y + 0{\cdot}5216\,x = 1{\cdot}597$	$+ 4\,\delta m$	9
1855	$y + 0{\cdot}7748\,x = 1{\cdot}444$	$+ 3\,\delta m$	4
1856	$y + 0{\cdot}9320\,x = 1{\cdot}260$	$+ 2\,\delta m$	4
1857	$y + 0{\cdot}9928\,x = 1{\cdot}458$	$+ \delta m$	9
1858	$y + 0{\cdot}9464\,x = 1{\cdot}250$		9
1859	$y + 0{\cdot}7488\,x = 1{\cdot}347$	$- \delta m$	9
1860	$y + 0{\cdot}5524\,x = 1{\cdot}358$	$- 2\,\delta m$	9
1861	$y + 0{\cdot}1780\,x = 1{\cdot}228$	$- 3\,\delta m$	4
1862	$y - 0{\cdot}0990\,x = 0{\cdot}717$	$- 4\,\delta m$	1
1863	$y - 0{\cdot}4236\,x = 1{\cdot}238$	$- 5\,\delta m$	9
1864	$y - 0{\cdot}6977\,x = 1{\cdot}404$	$- 6\,\delta m$	9
1865	$y - 0{\cdot}8958\,x = 1{\cdot}146$	$- 7\,\delta m$	4

Multiplying each equation by the corresponding value of w, and reducing the equations to two by the method of least squares, we have the following equations for the determinations of y and x:—

$$102\,y + 23{\cdot}149\,x = 141{\cdot}314 + 32\,.\,\delta m$$
$$23{\cdot}149\,y + 44{\cdot}560\,x = 32{\cdot}588 + 76\,.\,\delta m$$

From which we find

$$x = +\,0''{\cdot}013 + 1{\cdot}75\,.\,\delta m,$$

or

$$\text{Nutation constant} = 9''{\cdot}237 + 1{\cdot}75\,.\,\delta m.$$

Taking the mean of the determinations of the Nutation constant from the observations of *Cephei* 51 and *δ Ursæ Minoris*, we find for its value

$$9''{\cdot}1325 + 0{\cdot}88\,\delta m - 1{\cdot}8\,\delta c.$$

This value agrees almost identically with the value resulting from the discussion of the observations of *Polaris*, viz.:—

$$9''{\cdot}133 + 6{\cdot}1 \,.\, \delta p.$$

Taking the mean of these values as our final result, we find for the Nutation constant,

$$9''{\cdot}133 + 3{\cdot}05\,\delta p + 0{\cdot}44 \,.\, \delta m - 0{\cdot}90 \,.\, \delta c.$$

From the care bestowed upon the reduction of the observations to one uniform system, I am inclined to lay much more stress upon apparently small changes than would otherwise have been the case. I have been much surprised, therefore, to find that the colatitudes resulting from the yearly means of the observations of *Polaris*, above and below pole, differ considerably from the general average in an apparently systematic manner.

The observations of *Cephei* 51 and δ *Ursæ Minoris* are neither sufficiently numerous nor sufficiently well distributed to give very accurate determinations of the colatitude from year to year. The observations of *Cephei* 51, however, appear to give changes of colatitude something similar to those given by the observations of *Polaris*. In the case of the observations of δ *Ursæ Minoris* the corresponding changes are not well shown, or they are disguised so as not to be easily recognizable. The following table gives the corrections to colatitude, resulting from the observations of *Polaris* above and below pole, for the years 1851 to 1865:—

Corrections to Colatitude deduced from the Observations of *Polaris* above and below the pole.

Year.	Correction.	Number of Observations Above Pole.	Number of Observations Below Pole.
1851	+0″·351	75	56
1852	+0·246	66	75
1853	+0·370	51	55
1854	+0·573	86	98
1855	+0·423	65	68
1856	+0·315	73	66
1857	+0·207	91	92
1858	+0·236	124	107
1859	+0·408	106	104
1860	+0·377	65	57
1861	+0·102	93	80
1862	+0·139	55	57
1863	+0·021	69	68
1864	+0·196	68	87
1865	+0·218	40	54

If we assume that the variation of these corrections depends upon the position of the Moon's Node, or correction

$$
\begin{aligned}
&= z + r\cos(\Omega - q) \\
&= z + r\cos q\cos\Omega + r\sin q\sin\Omega \\
&= z + x\cos\Omega + y\sin\Omega,
\end{aligned}
$$

we have the following equations for the determinations of x, y, z. The probable errors of the results will be considered as equal.

$$
\begin{array}{ll}
1851 & z - 0{\cdot}439\,x + 0{\cdot}891\,y = +0{\cdot}351 \\
1852 & z - 0{\cdot}141\,x + 0{\cdot}986\,y = +0{\cdot}246 \\
1853 & z + 0{\cdot}218\,x + 0{\cdot}972\,y = +0{\cdot}370 \\
1854 & z + 0{\cdot}519\,x + 0{\cdot}850\,y = +0{\cdot}573 \\
1855 & z + 0{\cdot}781\,x + 0{\cdot}618\,y = +0{\cdot}423 \\
1856 & z + 0{\cdot}933\,x + 0{\cdot}348\,y = +0{\cdot}315 \\
1857 & z + 0{\cdot}997\,x + 0{\cdot}019\,y = +0{\cdot}207 \\
1858 & z + 0{\cdot}948\,x - 0{\cdot}303\,y = +0{\cdot}236 \\
1859 & z + 0{\cdot}785\,x - 0{\cdot}613\,y = +0{\cdot}408 \\
1860 & z + 0{\cdot}561\,x - 0{\cdot}822\,y = +0{\cdot}377 \\
1861 & z + 0{\cdot}231\,x - 0{\cdot}968\,y = +0{\cdot}102 \\
1862 & z - 0{\cdot}119\,x - 0{\cdot}988\,y = +0{\cdot}139 \\
1863 & z - 0{\cdot}419\,x - 0{\cdot}903\,y = +0{\cdot}021 \\
1864 & z - 0{\cdot}697\,x - 0{\cdot}711\,y = +0{\cdot}196 \\
1865 & z - 0{\cdot}872\,x - 0{\cdot}487\,y = +0{\cdot}218
\end{array}
$$

These equations lead to the following for the determination of $x\,y\,z$:—

$$
\begin{aligned}
15\,z + 3{\cdot}286\,x - 1{\cdot}111\,y &= +4{\cdot}182 \\
3{\cdot}286\,z + 6{\cdot}323\,x + 0{\cdot}912\,y &= +1{\cdot}447 \\
-1{\cdot}111\,z + 0{\cdot}912\,x + 8{\cdot}551\,y &= +0{\cdot}645
\end{aligned}
$$

which give

$$
\begin{aligned}
z &= +0{\cdot}270 \\
x &= +0{\cdot}074 \\
y &= +0{\cdot}103
\end{aligned}
$$

The sum of the squares of the corrected residuals,

$$= 0{\cdot}164878.$$

If we apply the mean value of z only, the sum of the squares of the residuals will equal

$$0{\cdot}280152,$$

or the error of mean square has been reduced from $0''{\cdot}136$ to $0''{\cdot}105$.

If this evidence be considered sufficient to indicate an apparent periodical change in the colatitude of the Greenwich Observatory, it may perhaps be taken as a proof of the yielding of the Earth's crust under the Moon's action, or referred to a systematic deformation of the atmosphere arising from the same cause. Very slight changes in the inclination of the general direction of the effective strata of the atmosphere would be sufficient to produce in the colatitude apparent variations of the required amount. It may, perhaps, not be out of place to recall the attention of astronomers to the results of the Rev. R. Main's attempts to determine the annual parallax of *γ Draconis.** From an elaborate discussion of the Greenwich Observations, extending over many years, made with two instruments of very different construction—Pond's Zenith Tube and Airy's Reflex Zenith Tube—the factor introduced to represent the annual parallax of *γ Draconis* came out a negative quantity. This anomalous result was deduced separately from a discussion of the observations with both these instruments.

Mr. Main's anomalous result for parallax might be explained by supposing that there exists a systematic deformation of the atmosphere with an annual period. The anomalies presented in the colatitude determinations from *Polaris* appear to be considerably diminished by supposing a systematic deformation of the atmosphere, with a period of 18 years. In this investigation an annual disturbance would, of course, be destroyed. It is curious, to say the least, that two investigations, which would appear the most favourable possible for the detection of systematic changes in the atmosphere, should each lead to anomalous results requiring apparently a very similar supposition for their explanation. I consider the discordances in the resulting colatitudes too systematic to arise from mere chance errors of observation.

***Greenwich*, 1868, *June* 12.**

Observations of the Lunar Crater IV. A$^{\epsilon}$ 17, IV. A$^{\zeta}$ 39.

By W. R. Birt.

The extreme interest attaching to the crater *Linné* has induced me to submit to the Society the accompanying observations, principally made by the Rev. W. O. Williams of Pwllheli, North Wales, of a crater near the middle of the Moon, which has manifested similar phenomena, and I do so the more readily as having computed the solar altitudes for twelve hour intervals at the latitude of the crater, viz. 5° S., I have arranged the existing observations in the order of solar altitudes, commencing with sunrise at the equinoxes, by which it will be easily seen that below certain altitudes the crater-form is distinctly and often conspicuously visible, while with higher altitudes the crater formed is entirely lost.

---

* *Memoirs*, vol. xxiv.; *Notices*, vol. xx. No. 7.

There are one or two points of interest connected with this crater. With altitudes under 25° the crater-form on some occasions has been lost, while on others, with altitudes between 30° and 36° it has been detected. The most remarkable phenomenon is the appearance of *two bright spots* seen at altitudes between 48° and 85°. On the subject of these spots a few remarks may probably be permitted.

These two bright spots were first seen by Mr. Williams on May 4, 1868, 10·30 to 11·30, G.M.T. It does not appear that any one has observed the crater previously at so high a solar altitude as 48°–54°. I also saw the two spots with the Crossley Equatoreal of 7·3 in. aperture on May 6, 1848, exactly as described by Mr. Williams, who observed them with an aperture of $4\frac{1}{16}$ inches, and noticed that there was a dark interval between them of about one-third of the diameter of either, they were about equal in brightness. Mr. Williams has seen them when the Sun was near its meridian altitude.

On Rutherford's Photogram, 1865, March 6, there is east of the spot IV. $\text{A}^{\alpha\,17}$, IV. $\text{A}^{\zeta\,39}$, a rather indistinct light circle with a somewhat dark interior, the whole very much less bright than IV. $\text{A}^{\alpha\,17}$, IV. $\text{A}^{\zeta\,39}$. It is possible that the east of the two bright spots may be this which favourable circumstances have rendered more distinctly visible as well as *brighter*. On Mr. De La Rue's Photogram, 1865, Oct. 4, IV. $\text{A}^{\alpha\,17}$, IV. $\text{A}^{\zeta\,39}$, is an *elongated* white spot, the elongation is towards the valley IV. $\text{A}^{\zeta\,96}$, which agrees with the line joining the two spots seen by Mr. Williams.

The spot IV. $\text{A}^{\alpha\,17}$, IV. $\text{A}^{\zeta\,39}$, is thus described in the British Association Lunar Catalogue,—

"A bright spot SSW of IV. $\text{A}^{\alpha\,7}$, 5″·94, Mag. 0·37, probably a crater on the NE. border of *Hipparchus*." Latitude 5° S.; longitude 2° W.

Note.—IV. $\text{A}^{\alpha\,7}$ is *Hipparchus F.* of Beer and Mädler.

Observations of IV. $\text{A}^{\alpha\,17}$, IV. $\text{A}^{\zeta\,39}$. Latitude 5° S.; Longitude 2° W.

Morning illumination.

No.	Year.	Date, G.M.T.	Authority.	Sun's Alt.	Brightness.	Character.
1	1867	May 11, 8½	Birt	0°–6°	...°	A shallow crater.
2	1868	Feb. 1, 5–6	Williams	6–12	...	Crater well seen.
3	1868	March 31, 7½	Birt	6–12	...	Crater well defined.

No.	Year.	Date G.M.T.	Authority.	Sun's Alt.	Bright-ness.	Character.
4	1868	Jan. 3, 5–6	Williams	12°–18°	...°	Discerned central cone, but not certain.
5	1868	Jan. 3	Baxendell	12–18	...	A well-marked, shallow crater.
6	1867	Nov. 5, 9–10	Williams	18–24	7	Very bright streak of interior shadow on the west.
7	1868	April 1, 5–6	Williams	18–24	4	Whitish patch of light.
8	1867	Dec. 5, 6–8	Williams	24–30	5	Whitish spot; no crater.
9	1868	May 1, 10–11	Williams	24–30	...	Whitish patch; line of interior shadow on the west.
10	1867	Oct. 7, 8½–10	Williams	24–30	...	A very bright spot.
11	1867	Nov. 6, 8–10	Williams	30–36	6	A bright patch of light; streak of shadow scarcely discernible.
12	1868	April 2, 5–6	Williams	30–36	4	Whitish patch of light.
13	1868	April 2, 8½	Birt	30–36	4	A very shallow crater, with interior shadow,
14	1867	Dec. 6, 9–10	Williams	36–42	5	Whitish spot; no crater.
15	1868	May 2, 6½–10	Williams	36–42	...	Long patch of light to the E.
16	1868	May 4, 10½–11½	Williams	48–54	...	*Two* bright spots.
17	1868	May 5, 10½–11½	Williams	60–66	...	*Two* nearly equal and circular bright spots.
18	1868	May 6, 9¾–10¼	Birt	72–78	...	*Two* bright spots.
19	1868	May 7, 11¼–12	Williams	83–85	...	*Two* bright spots, the east largest.

Evening illumination.

No.	Year.	Date, G.M.T.	Authority.	Sun's Alt.	Bright-ness.	Character.
20	1867	Nov. 15, 18–20	Williams	36–30	10°	Very bright.
21	1868	Feb. 12, 20½	Williams	30–24	6, 4	Crater very conspicuous, with east peak very bright.
22	1867	Oct. 17, 13–15	Williams	30–24	...	Crater very conspicuous.
23	1867	Oct. 17, 13½	Ingall	30–24	...	Drawn as a crater.
24	1867	Oct. 18, 17–19	Williams	18–12	...	Crater very conspicuous; small central cone casting a shadow.
25	1868	Jan. 15, 20½	Williams	12–6	...	The crater conspicuous, with interior shadow on east fully equal to that of IV. A ^{a}7.

On certain partial Lunar Eclipses not noticed in the Nautical Almanac. By R. A. Proctor, B.A.

When there is a total or partial eclipse of the Moon by the Earth's umbra, the times of first and last contact with the penumbra are recorded in the *Nautical Almanac.* But when the Moon passes wholly or in part within the penumbra without touching the umbra, no notice is taken of the phenomenon. This seems a defect, for the penumbral passages have now an evident value on account of the application of spectroscopic analysis. Also, there seems something defective in the theory of eclipses, as presented in works on Astronomy, in which, so far as I have seen, no notice whatever is taken of penumbral lunar eclipses. It may readily be shown that when these eclipses are taken into account, the total number of lunar eclipses in any long period slightly exceeds, instead of falling considerably short of, the number of solar eclipses.

It should be noticed that when a solar eclipse occurs alone—that is, without a lunar eclipse at the preceding or following full Moon—the Moon is always penumbrally eclipsed at one of these epochs, and more commonly at both of them. So that, when there are only two eclipses in the year—in which case both are solar—there are frequently *four* penumbral lunar eclipses, and there must be two such phenomena.

In the present year there are only two solar eclipses: one of these was annular and occurred in February, the other is the great total eclipse of August 17th next. The Moon will be penumbrally eclipsed both before and after the great eclipse. The former penumbral eclipse will not be visible in England; the latter I give the elements of this eclipse as deduced from an approximate calculation and projection:

		h	m	s
Greenwich Mean Time of Opposition in R.A. Sept. 1		14	54	0
Moon's Right Ascension		22	45	40·7
		°	′	″
Moon's Declination	S.	9	11	13·7
Sun's Declination	N.	7	52	14·5
Moon's Hourly Motion in R.A.			28	55·5
Sun's Hourly Motion in R.A.			2	15·8
Moon's Hourly Motion in Decl.	N.		8	45·2
Sun's Hourly Motion in Decl.	S.			54·8
Moon's Equatoreal Horizontal Parallax			54	11·4
Sun's Equatoreal Horizontal Parallax				8·9
Moon's True Semi-diameter			14	47·5
Sun's True Semi-diameter			15	53·8

These values, applied in the usual manner to the projection of the eclipse, give the following results:—

	h	m
First Contact with the Penumbra, Sept. 1st	14	16
Middle of the Eclipse	15	43
Last Contact with the Penumbra ..	17	10

Magnitude of the Penumbral Eclipse (Moon's Diameter = 1) 0·33

The first contact with the penumbra occurs at 11° 15′ from the northernmost point of the Moon's limb towards the east.

The last contact at 44° 20′ towards the west.

At the time of central eclipse the penumbra intersects the Moon's limb at points 49° 40′ from the north towards the east, and 83° from the north towards the west. The middle of the shadow lies, therefore, 16° 40′ from the north point towards the west. (In all cases for direct image.)

I take this opportunity of remarking that, during a total lunar eclipse, a portion of the faint light still received from the Moon is probably due to the Sun's corona; and, therefore, the spectroscopic examination of the Moon at such a time might have interesting results. During some total eclipses the Moon has been wholly obliterated from view, even with telescopes having considerable light-gathering power. It might be interesting to inquire how far this peculiarity bears on our views respecting the corona.

I wish also to call the attention of observers of the Sun to the importance of carefully noting the appearance of the solar disk from the 14th to the 20th of August. The observers of the Great Eclipse on the 17th will, doubtless, record the exact positions of the rose-coloured prominences around the Sun's disk; and the comparison of such observations with the recorded positions and motions of solar spots and faculæ may possibly serve to exhibit some such association as has been suspected between the coloured prominences and the solar spots.

Minor Planet, (96) Œgle.

The following elements calculated from observations of 17 Feb., at Marseilles, and 1 and 14 March, at Leipzig, by Herr Vogel, are given *Ast. Nach.*, No. 1687.

1868, March 1·5, Berlin M.T.

$$
\begin{array}{rl}
M = & 346^\circ\ 34'\ 42''\!\cdot\!0 \\
\left.\begin{array}{r} \pi = \\ \Omega = \\ \iota = \end{array}
\begin{array}{r} 165\ 14\ 32\cdot7 \\ 322\ 49\ 25\cdot9 \\ 16\ \ 5\ 41\cdot7 \end{array}\right\} & \begin{array}{l}\text{Mean Equin.}\\ 1868\cdot0.\end{array} \\
\varphi = & 8\ \ 8\ 16\cdot8 \\
\log a = & 0\cdot485130 \\
\mu = & 664''\!\cdot\!220.
\end{array}
$$

Minor Planet, (97) Clotho.

The following elements, calculated by Dr. Maywald from Normal Places of March 1 and 30, and April 28, are given *Ast. Nach.*, No. 1696.

Epoch 1868, Jan. 0·0, Berlin M.T.

$$\begin{array}{rl}
M_0 = & 60^\circ\ 44'\ 22''\cdot 80 \\
\lambda_0 = & 126\ \ 21\ \ 10\cdot 45 \\
\omega + \Omega = & 65\ \ 36\ \ 47\cdot 65 \\
\Omega = & 160\ \ 35\ \ 26\cdot 88 \\
i = & 11\ \ 43\ \ 29\cdot 78 \\
\phi = & 14\ \ 26\ \ 13\cdot 84 \\
\log a = & 0\cdot 4258793 \\
\mu = & 815''\cdot 0564.
\end{array}$$

Minor Planet, (98) *Ianthe.*

Discovered by Prof. C. H. F. Peters, Clinton, N.Y., on the 18 April. The following elements calculated by him from observations of April 18, 22, and 26, are given *Ast. Nach.*, No. 1695.

Epoch 1868, April 30·0, Berlin M.T.

$$\begin{array}{rl}
M_0 = & 6^\circ\ 18'\ 49''\cdot 8 \\
\left.\begin{array}{r} \pi = \\ \Omega = \\ i = \end{array}\begin{array}{l} 180\ \ 59\ \ 48\cdot 0 \\ 353\ \ 41\ \ \ 1\cdot 1 \\ 15\ \ \ 8\ \ \ 1\cdot 9 \end{array}\right\} & \text{Mean Equin. } 1868\cdot 0. \\
\phi = & 12\ \ \ 3\ \ \ 2\cdot 54 \\
\mu = & 726''\cdot 603 \\
\log a = & 0\cdot 4591396
\end{array}$$

A telescope presented to the Society by Mr. Baker, Optician, High Holborn, was exhibited at the Meeting. The following is Mr. Baker's letter addressed to Mr. Huggins, Secretary of the Society:—

"I have recently come into possession of the earliest formed equatoreal instrument, which I believe to be one of three alluded to by Mr. Short in his letter to the Royal Society of Dec. 7, 1749 (see *Philosophical Transactions* of that year, p. 241). It consists of a Gregorian telescope mounted upon a universal stand, with hour and declination circles, and is, to all appearance, in its original state.

"It has occurred to me that this instrument would probably be acceptable to the Royal Astronomical Society, and would be deemed worthy of a place in their Museum of Instruments; if such should be the case, I shall have much pleasure in presenting it to the Society, and have forwarded it to their Apartments for the inspection of the Council."

It was, at the Meeting of the Council, resolved that the thanks of the Council be given to Mr. Baker for his valuable addition to the Society's collection of instruments.

Observations and Elements of Comet. By Dr. A. Winnecke.

The new Comet has been observed by me on every night since its discovery, June 13; the measures are the following:—

(Latitude 48° 59′ 44″; Longitude 20ᵐ 14ˢ West of Berlin.)

1868.	Karlsruhe M.T.	Comet—Star.		α Comet.	δ Comet.	No. of Comp.	Star.
	h m s	m s	′ ″	h m s	° ′ ″		
June 13	13 21 26	+0 30·80	−28 43·6	3 7 55·76	+47 18 29·7:	4	*b*
13	14 15 42	−2 14·93	− 1 49·4	3 8 15·22	47 21 10·7	4	*c*
14	13 36 18	+0 31·82	+ 0 43·2	3 15 6·58	48 20 28·9	8	*d*
15	14 25 54	+1 28·37	− 1 31·2	3 23 29·33	49 25 5·7	6	*e*
16	13 3 44	+0 26·17	+ 1 47·0	3 32 12·67	50 24 57·8	8	*f*
17	11 34 42	+3 14·50	+ 0 2·1	3 42 2·98	+51 24 36·7	2	*g*

Adopted Mean Places of Stars of Comparison, 1868·0.

	h m s	° ′ ″	
b	α = 3 7 25·05	δ = +47 47 25·6	Argel. vol. vi.
c	3 10 30·24	47 23 12·3	Radcliffe 922
d	3 14 34·83	48 19 57·1	Argel. Zone 64, No. 61
e	3 22 1·09	49 24 3·6	Argel. vol. vi.
f	3 31 46·50	50 23 10·8	Argel. Zone 71, No. 1
g	3 33 48·67	+50 24 47·1	Radcliffe 1066

The first comparison of the Comet was made with an anonymous star 9.10 mag., and therefore not yet reduced. The instrument used is a refractor of 5 inches aperture by Hertel and Reinfelder, at Munich, with ring micrometer.

From June 13, 15, 17, I have found the following elements of the orbit:—

T = 1868, June 25·9316 Berl.

π = 287° 8′ 17″·8

☊ = 53 18 48·6 1868·0

i = 48 9 12·4

log q = 9·765094

Retrograde.

Middle Observ. $(l' - o)$ $\Delta\lambda = +2''\cdot2$ $\Delta\beta = -2''\cdot7$

The splendour of the Comet increases rapidly; it is this night visible to the naked eye as a star of the 5th magnitude. The tail is 2 degrees long in the sweeper.

Karlsruhe, 1868, *June* 18.

The North German expedition for the observation of the Solar Eclipse of August 18 was to start from Berlin on the evening of Wednesday, July 8. The funds for this expedition are provided by the Norddeutscher Bundesrath, and it is understood that the general superintendence of the expedition rests with a resident Commitee of the Astronomische Gesellschaft. The astronomers will land at Bombay, and will probably take a station considerably to the west of those taken by the British parties. In the selection of station, and in the arrangement of their journeys, they have been assisted by the advice of our best Indian scientific authorities.

The Editor has received from M. Hoek a list of Errata in the paper "On the Phenomena of Meteors:" this will be printed in the next Number.

ERRATUM.

P. 8, line 22, for *Uranus* read *Saturn*.

CONTENTS.

Page
Fellows elected 225
On the Variable Star η *Argûs* and its surrounding Nebula, by Sir J. F. W. Herschel, Bart. ... ... ib.
A Determination of the Constant of Nutation from the observations in N.P.D. of *Polaris*, *Cephei* 51, δ *Ursæ Minoris*, made with the Transit Circle of the Royal Observatory, Greenwich, 1851–1865, by Mr. Stone 229
Observations of the Lunar Crater IV. $A^{\alpha 17}$, IV. $A^{\zeta 39}$, by Mr. Birt ... 237
Of certain partial Lunar Eclipses not noticed in the *Nautical Almanac*, by Mr. Proctor 239
Minor Planet, (96) *Œgle* 241
,, ,, (97) *Clotho* ... ... ib.
,, ,, (98) *Ianthe* 242
Telescope presented to the Society by Mr. Baker ... ... ib.
Observations and Elements of Comet, by Dr. Winnecke 243
The North German Expedition to India 244
Erratum ... ... ib.

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MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

Vol. XXVIII. *Supplementary Notice.* No. 9.

The Total Solar Eclipse of August 17–18, 1868.

(Extract of a Letter from Major J. F. Tennant, R.E. to the Astronomer Royal.)

Guntoor, August **18, 1868.**

"This morning was very promising, and if it had followed the course of its predecessor, we should have had a magnificent clear sky, but it clouded over the east with thin cumulostrati, which, while hardly stopping vision, interfere very much with the photographic energy; and the result was that every negative was under-exposed, and we have little more than very dense marks showing the protuberances. The six plates arranged for were duly exposed, but the heat so concentrated the nitrate-of-silver solution, that, besides showing but faint traces of any corona, they are all covered with spots. Still we may make something of them, and will try.

"Capt. Branfill reports the protuberances unpolarised, and the corona strongly polarised everywhere in a plane passing through the centre of the Sun.

"Complementarily I have to report a continuous spectrum from the corona, and one of bright lines from the prominence I examined. I am, I believe, safe in saying that three of the lines in the spectrum of the protuberances correspond to C, D, and *b*. I saw a line in the green near F, but I had lost so much time in finding the protuberance (owing to the finder having changed its adjustment since last night) that I lost it in the sunlight before measuring it, and I believe I saw traces of a line in the blue near G, but to see them clearly involves a very large change in the focus of the telescope, which was out of the question then.

"I conclude that my result is that the atmosphere of the Sun is mainly of non-luminous (or faintly luminous) gas at a short distance from the limb of the Sun. It may have had faintly luminous lines, but I had to open the jaws a good deal to get what I could see at first, and, consequently, the lines would be diffused somewhat, still I think I should have seen them. The prominence I examined was a very high narrow one, almost to my eye like a bit of the Sun through a chink in brightness and colour (I could see no tinge of colour), and somewhat zigzagged like a flash of lightning. It must have been three minutes high, for it was on the preceding side of the Sun near the vertex, and was a marked object, both in the last photo-plate just before the Sun reappeared, and to the eye.

"Captain Branfill saw the prominences coloured, as did two other gentlemen, but one in my Observatory (like myself) only saw it white. I should, however, say that for long I never saw *α Orionis* markedly red, nor *Antares*, and I may not catch red soon, though I cannot conceive this being so.

"In conclusion, I may note that the darkness was very slight, and the colour not half so gloomy as in the eclipse of 1857, which was partial at Delhi, where I was then."

On the Cluster in Perseus. By Dr. O. Pihl.

I have the honour of laying before the Society the results of a micrometric examination of the Stellar Cluster in *Perseus*, commonly designated 65 *Bode* or 34 *Messier*, which I have been prosecuting since the year 1860, with a view to obtain, within comparatively small probable errors, a mensuration of all the more conspicuous stars, sufficiently exact to serve as a basis for investigating, at some remote date, the mechanism of the system.

The instrument employed is a Refractor, with 3¼ inch aperture, by H. Krog, of Bergen, equatoreally mounted by Lohmeyer of Hamburg. Owing to the stars under examination, with three or four exceptions, being of a magnitude too low for the employment of a wire-micrometer with illuminated field, and the instrument not being provided with an arrangement for the illumination of the wires upon a dark field, I have been reduced to the exclusive use of bar-micrometers (Boguslawski's), with magnifying powers of 40 and 120, and to a ring-micrometer, with a magnifying power of 40; the latter, however, has been used to a less extent.

All the measurements have been referred to one particular star (No. 25 in the list) on the southern side of the group; the *absolute* position of which, as well as that of the secondary star (No. 33) on the northern side, required for using the Boguslawski micrometer, has been determined by recent observations by Argelander and Fearnley, as also by myself.

From these two fundamental stars a triangulation of the whole group has been performed, principally with the bar-micrometer, and in effecting this I have, for convenience, in addition to the two above-named stars, employed nineteen others, partly for obtaining the Right Ascension and partly for the Declination. These stars have been examined with special care with reference to the two fundamental stars; and the probable error of their positions in that co-ordinate, for the determination of which for other stars they have been employed, does not generally amount to $0''\cdot25$ of Great Circle.

A number of observations have been taken with the ring-micrometer, mostly with a specific object in view; for instance, the determination of very small differences in Declination. The total number of stars whose positions have been measured is 85; the probable errors in no case amount to $0''\cdot5$ of arc of Great Circle in either co-ordinate; the mean probable error being in R.A. = $0''\cdot298$, and in Decl. $0''\cdot309$. The positions in R.A. and in Decl. have in the majority of cases been obtained by separate observations, the number of which, exclusive of those taken for obtaining the absolute positions, is as follows:—For R.A. 541 sets in all, or 65 on an average for each star; for Decl. 461 sets in all, or 5·5 on an average for each star; but of the latter observations, 418 have been taken with the bar-micrometer, and with that number of sets in either of the two opposite oblique positions of the bar. Each set consists, in the majority of cases, of from six to eight passages across the field.

So large a number of observations was necessary in order to ensure the accuracy required, more especially as the limited size of the instrument and the nature of the micrometers employed are not favourable for obtaining exact results with but few observations.

Having no Meridian Circle at my disposal, I have had to adopt a circuitous and somewhat laborious method for determining the absolute position of the group, and for that purpose resorted to *γ Andromedæ*, the position and proper motion of which have been closely determined by several of the most distinguished of modern astronomers;* this star, at a distance of about 38^m preceding the centre of the group, having a Declination of about $30'$ of arc south of two of the larger stars in the system.

By means of the ring-micrometer (with a mean radius of $1023''\cdot79$) the Declination of these two stars, with reference to *γ Andromedæ*, was found by eleven passages of each. The Right Ascension of three other stars, more favourably situated for that purpose than the two above-named, was determined, on an average, by eight passages of each.

However, being sensible of the numerous chances of error in this mode of determining the position with comparative exactness, I applied to my friend, Professor Fearnley, Director of the Royal Observatory, Christiania, who, by means of the Meridian Circle, kindly obtained the positions of two of the northern, and two of the southern, stars, including the two fundamental stars (Nos. 25 and 33), referred to above.

---

* Mädler: "Der Fixsternhimmel," p. 23.

Having noticed in the *Astronomische Beobachtungen* of the Bonn Observatory, that three of the northern stars in the group had been measured by the Meridian Circle of that establishment, among which were the two observed by Professor Fearnley, I wrote to Professor Argelander, who most obligingly furnished me with his positions, as also with the Right Ascension of two other stars. On my own measurements of Right Ascension of the above three stars, by means of γ *Andromedæ*, whose position had been determined with a probable error of $0^{s}{\cdot}023$, I felt safe in placing a considerable degree of reliance; and as Argelander's and Fearnley's positions, in that co-ordinate, of one of the two stars obtained by both, did not agree very well, whereas my positions, both for this star and for the second measured by those astronomers, — and with regard to which they agree closely,— was not far from the mean of their results ($0^{s}{\cdot}094$ and $0^{s}{\cdot}058$ respectively), I have felt justified in using my own results, as well as those of Argelander and Fearnley, for finally determining the absolute Right Ascension.

But in finding the absolute Declination, I have totally rejected my own results, determined by γ *Andromedæ*, which, however, within $2''$ agree with the mean of Argelander and Fearnley's positions: for in this co-ordinate two causes of error are present which cannot be eliminated, viz., the error arising from the error in value of the dimensions of the ring of the micrometer, and the error to be anticipated from the vast difference between the intensity of light in γ *Andromedæ* and of the stars compared with it,— an error which, with so large a difference in Declination, could not be neutralised by measuring the pairs of stars in the upper and lower part of the ring alternately.

By combining Argelander's and Fearnley's results with my own, the ultimate value obtained in Right Ascension varies in four stars from $+0^{s}{\cdot}219$ to $+0^{s}{\cdot}328$, and in one (No. 33) the difference is $-0^{s}{\cdot}011$ from those of Argelander's. It may, however, be observed, that the first four of these stars have been observed by Argelander only on one evening, and upon only one to three wires, whereas the last has been observed on two occasions, and, on one of these, upon seven wires. On the other hand, the above ultimate value varies from $-0^{s}{\cdot}105$ to $-0^{s}{\cdot}247$ from Fearnley's Right Ascensions.

By combining the positions in Declination of the four stars measured by Fearnley, and of the two by Argelander, with my own *relative* positions of these stars, the resulting values vary from $+0''{\cdot}50$ to $-1''{\cdot}30$ from Fearnley's, and are $+0''{\cdot}08$ and $2''{\cdot}28$, respectively, at variance with Argelander's positions; the former difference being for the star No. 33, observed by Argelander with the four microscopes, whereas the latter was observed with only one.

The main object of my investigation being to determine the *relative* positions of the individual stars, they have all, as previously observed, been referred to a single star (No. 25) in the southern part of the group.

In the following Catalogue the positions with respect to that star are, therefore, given,—in R.A. in seconds of time, and in Decl. in seconds of arc,—but separate columns also contain the absolute positions.

The Probable Error of each position is specified: with regard to R.A. this error is expressed in time, and in an adjacent column reduced to arcs of Great Circle.

In the calculation of the Probable Errors, due reference has been paid to the relative value of each observation entering into the calculation; the formula employed being

$$\text{P. E.} = 0{\cdot}67449\sqrt{\frac{n\,\Sigma\,\Delta^2}{\left(n-1\right)\left(\frac{1}{p_1}+\frac{1}{p_1}\,..\,\frac{1}{p^n}\right)\left(p_1+p_2\ldots p_n\right)}},$$

or, for sets with each observation of equal value, the reduced form,

$$\text{P. E.} = 0{\cdot}67449\sqrt{\frac{\Sigma\,\Delta^2}{n\,(n-1)}},$$

n denoting the number of observations, and $p_1\ p_2 \ldots p_{n_2}$ the relative values of the separate observations entering into the calculation.

The constants employed for the calculation of Precession are those of Bessel.

With regard to the magnitude of the stars, I have endeavoured to express them according to Argelander's standard.

The Positions of Bessel in the last column of the Table are reduced from those given in the *Königsberger Beobachtungen*, vol. xvii.: for Zone 529, the corrections given in Cat. II. by Weisse, have been taken into account. It will be observed, that these positions, and specially the positions *inter se* of these seven stars of Bessel's, are, within amounts not altogether slight, at variance with those I have found to exist at the present time. I am aware that it would be premature to conclude from these differences any proper motions of the stars; but, at the same time, the differences are, no doubt, large enough to deserve special notice. In Declination, for instance, Bessel's position for No. 12 differs $-9''{\cdot}67$ from mine; for No. 25 $-2''{\cdot}01$; for No. 60 $+2''{\cdot}41$; for No. 82 $-7''{\cdot}04$, &c. Bessel's difference in Declination between No. 12 and No. 60 is, therefore, upwards of 12″, and between No. 60 and No. 82, about $9''{\cdot}5$ at variance with mine,—differences which appear somewhat suspicious. They are, undoubtedly, very large, if supposed to arise merely from errors in observation,—considering that Bessel's mean Probable Errors in Declination in his Zone Observations are, so far as I am aware, only about $1''{\cdot}5$, and that the mean Probable Error in my observations of these stars is only 0″·21. It might be inferred that, as Bessel's Declinations are, in all cases but one,— namely, in that of No. 60, more southerly than those obtained by means of Argelander and Fearnley's Meridian Observations,— the exception, as regards No. 60, may be owing to an error in the reading off of the Declination of that star,— a supposition which the Declination given by Lalande would seem to corroborate. But, on the other hand, it may be remarked that Bessel has measured Nos. 25 and 60 on the same evening, and, consequently, the one immediately after the other, and that yet he has placed No. 60 3″·30 *north* of No. 25; while now it is, according to my measurement, 0″·93, and, according to Fearnley, even 2″·75 *south* of it. Now, if the probable error of a single star in Bessel's Zone Observations is in Decl. = 1″·5, the mean probable error of the above seven stars would be 0″·6. But the mean Declination of Bessel's seven stars is 4″·27 south of the mean Declination now determined. Is it probable that this difference is owing merely to errors in observation, or to errors in the constants, notwithstanding Weisse's revision of Bessel's Tables of Reduction, and to no physical change? Of course this cannot now be answered; but I trust that the examination, the results of which are contained in the preceding Catalogue, may, on some future investigation, be the means of successfully solving the problem, as regards the mutual proper motions of the stars in this extensive system.

On the Plate representing the group, I have, in addition to the stars measured, marked all other stars (117 in number), which, under the most favourable circumstances, can be seen or sighted in my instrument. Their positions have no claim to accuracy beyond that of careful sketches. The 85 stars numbered on the plate have alone been measured and laid down accordingly.

Tulliubjerget, Christiania, June 26, 1868.

			Right Ascension.		Prob. Error.		Yearly Precession.		Declination.	
No.	Mag.	No. of Obs.	Mean R.A. 1865·0.	R.A. refer. to No 25.	Secs. of Time.	Secs. of Gt. Circ.	1865·0.	Secul. Change.	No. of Obs.	Mean Decl. 1865·0.
			h m s		s	″	s	s		° ′ ″
1	10.4	7	2 31 50·286	−62·682	0·041	0·46	3·8172	+0·0396	4	42 13 26·20
2	9.9	6	56·069	56·899	·039	·43	·8181	·0396	4	42 14 36·90
3	10.4	4	59·086	53·882	·027	·30	·8192	·0396	6	42 16 35·7
4	10.1	4	32 10·725	42·243	·018	·20	·8162	·0397	4	42 7 59·28
5	9.8	4	11·886	41·082	·024	·27	·8222	·0398	4	42 21 36·72
6	10.7	5	13·974	38·994	·026	·29	·8158	·0395	4	42 6 39·84
7	8.8	8	19·383	33·585	·020	·23	·8209	·0397	6	42 17 21·12
8	10.3	4	19·813	33·155	·022	·25	·8196	·0396	4	42 14 23·34
9	8.7	9	22·844	30·124	·020	·23	·8221	·0398	5	42 19 25·98
10	9·7	4	24·871	28·097	·015	·17	·8241	·0399	5	42 23 46·18
11	10.0	5	27·534	25·434	·039	·43	·8161	·0394	4	42 5 5·09

No.	Mag.	No. of Obs.	Right Ascension. Mean R.A 1865·0.	Right Ascension. R.A. refer. to No. 25.	Prob. Error. Secs. of Time.	Prob. Error. Secs. of Gt. Circ.	Yearly Precession. 1865·0	Yearly Precession. Secul. Change.	Declination. No. of Obs.	Declination. Mean Decl. 1865·0.
			h m s		s	″	s	s		° ′ ″
12	8.7	18	2 32 32·123	−20·845	0·014	0·16	3·8168	+0·0394	7	42 5 46·83
13	10.7	4	34·017	18·951	·018	·20	·8252	·0399	4	42 24 47·47
14	10.7	6	34·329	18·639	·043	·48	·8248	·0399	4	42 23 52·69
15	10.5	4	37·448	15·520	·020	·23	·8251	·0399	7	42 23 59·74
16	9.5	6	38·312	14·656	·032	·36	·8184	·0395	6	42 8 38·24
17	10.7	4	40·601	12·367	·019	·22	·8258	·0399	6	42 25 4·02
18	9.3	7	41·075	11·893	·021	·24	·8226	·0397	5	42 17 47·81
19	10.5	4	41·392	11·576	·018	·21	·8211	·0396	4	42 14 13·07
20	10.7	5	43·664	9·304	·041	·46	·8254	·0398	4	42 23 43·36
21	10.4	4	44·106	8·862	·023	·26	·8141	·0392	5	41 57 37·58
22	9.4	4	44·486	8·482	·016	·18	·8213	·0396	4	42 14 12·17
23	9.4	4	45·978	6·990	·022	·25	·8220	·0396	4	42 15 41·94
24	9.9	8	50·211	2·757	·034	·38	·8149	·0392	4	41 58 45·01
25	8.0	...	52·968	0·000	...	...	·8160	·0393	...	42 0 45·47
26	9.3	4	59·345	+ 6·377	·027	·30	·8273	·0399	4	42 25 28·01
27	9.4	6	59.695	6·727	·021	·24	·8240	·0397	7	42 17 55·06
28	10.0	5	33 0·820	7 852	·042	·47	·8195	·0395	5	42 7 29·99
29	9.6	4	1·897	8·929	·017	·19	·8213	·0396	5	42 11 29·00
30	10.2	7	7·743	14·775	·033	·37	·8201	·0395	5	42 8 6·28
31	8.3	18	8·780	15·812	·015	·17	·8218	·0396	10	42 11 26·20
32	10.6	4	10.974	18·006	·029	·33	·8243	·0397	5	42 16 48·47
33	7.8	...	14 345	21·377	...	...	·8284	·0399	...	42 25 36·01
34	10.1	5	15·326	22·358	·022	·25	·8196	·0394	5	42 5 33·85
35	8.0	4	16·896	23·928	·013	·15	·8229	·0396	8	42 12 35·76
36	8.0	20	18·637	25·669	015	·17	·8230	·0396	5	42 12 43·60
37	10.2	5	19·779	26·811	·038	·42	·8195	·0394	4	42 4 29·36
38	8.9	6	22·090	29·122	·030	·33	·8221	·0395	5	42 10 7·27
39	10.4	5	23·773	30·805	·031	·34	·8161	·0392	4	41 56 8·23
40	9.2	11	25·007	32·039	·029	·32	·8171	·0392	9	41 58 0·42
41	7.7	10	26·080	33·112	·013	·15	·8213	·0395	13	42 7 39·70
42	9.8	4	26·755	33·787	·032	·35	·8229	·0395	5	42 11 10·52
43	8.8	6	30·434	37·466	·023	·26	·8249	·0396	8	42 15 11·04
44	10.3	5	30·660	37·692	·035	·39	·8228	·0395	4	42 10 25·06
45	9.3	9	32·355	39·387	·028	·31	·8238	·0396	4	42 12 26·87
46	8.7	6	33·330	40·362	·030	·33	·8228	·0395	7	42 10 2·33
47	7.7	12	33·487	40·519	·012	·14	·8216	·0395	12	42 7 11·67
48	8.3	7	33·590	40·622	·025	·28	·8237	·0396	5	42 11 55·33
49	10.2	5	33·809	40·841	·024	·27	·8196	·0393	4	42 2 30·64
50	8.6	4	34·085	41·117	·028	·31	·8260	·0397	6	42 17 12·91
51	9.3	7	34·181	41·213	·037	·41	·8264	·0397	7	42 17 4·96
52	10.3	5	36·532	43·564	·043	·48	·8266	·0397	4	42 18 1·07
53	10.4	6	37·863	44·895	·031	·34	·8193	·0393	4	42 1 19·71

No.	Mag.	No. of Obs.	Right Ascension. Mean R.A. 1865·0 h	m	s	R.A. refer. to No. 25.	Prob. Error. Secs. of Time.	Secs. of Gt. Circ.	Yearly Precession. 1865·0	Secul. Change.	Declination. No. of Obs.	Mean Decl. 1865·0. °	′	″
			h	m	s		s	″	s	s		°	′	″
54	8.3	6	2	33	42·248	−49·280	0·028	0·31	3·8237	+0·0395	7	42	10	51·93
55	10·2	5			43·564	50·596	·038	·42	·8197	·0393	4	42	1	16·17
56	8.4	9			47·272	54·304	·019	·22	·8241	·0395	6	42	10	45·66
57	10.2	6			50·397	57·429	·021	·24	·8202	·0393	5	42	1	19·84
58	9.3	5			50.576	57·608	·025	·28	·8300	·0398	4	42	23	35·67
59	10.3	7			54·887	61·919	·037	·41	·8244	·0395	4	42	10	·04
60	7.2	11			55·659	62·691	·020	·23	·8203	·0393	18	42	0	44·55
61	9.4	4			56·031	63·063	·023	·26	·8288	·0397	4	42	20	5·37
62	10.2	5			58·912	65·944	·032	·35	·8268	·0396	4	42	15	5·63
63	10.4	6		34	4·415	71·447	·037	·41	·8270	·0396	8	42	14	46·39
64	7.9	12			5·362	72·394	·019	·22	·8270	·0396	8	42	14	31·39
65	10.1	5			5·643	72·675	·030	·33	·8239	·0394	6	42	7	16·80
66	9.9	6			8·012	75·044	·027	·30	·8235	·0394	5	42	6	6·00
67	10.2	6			11·328	78·360	·024	·27	·8211	·0393	5	42	0	11·09
68	10.3	6			11·547	78·579	·035	·39	·8249	·0395	4	42	8	47·03
69	9.5	5			12·381	79·413	·032	·35	·8220	·0393	4	42	2	3·63
70	10.6	4			13·592	80·624	·011	·13	·8208	·0393	6	41	59	10·01
71	10.0	7			15·761	82·793	·035	·39	·8277	·0396	5	42	14	27·08
72	9.9	4			18·916	85·948	·016	·18	·8299	·0397	4	42	19	2·93
73	8.3	20			20·089	87·121	·015	·17	·8331	·0399	12	42	26	0·83
74	10.6	7			30·646	97·678	·031	·34	·8222	·0393	5	41	59	50·82
75	10.6	7			33·387	100·419	·029	·32	·8233	·0393	5	42	0	40·55
76	9.8	4			34·478	101·510	·010	·12	·8326	·0398	6	42	22	29·63
77	9.8	4			36·242	103·274	·032	·35	·8299	·0396	4	42	16	16·67
78	9.6	5			38·466	105·498	·038	·42	·8285	·0395	4	42	12	46·40
79	10.4	6			38·823	105·855	·030	·33	·8268	·0394	4	42	8	52·13
80	8.7	7			45·071	112·103	·023	·26	·8285	·0395	6	42	11	46·00
81	10.0	5			50·147	117·179	·036	·40	·8295	·0395	5	42	13	8·90
82	8.4	12			52·256	119·288	·025	·28	·8250	·0393	9	42	2	40·22
83	10.0	7		35	1·011	128·043	·036	·40	·8295	·0395	4	42	11	29·25
84	10.7	4			5·836	132·868	·027	·30	·8300	·0395	4	42	11	58·55
85	10.3	6	2	35	19·026	−146·058	0·039	0·43	3·8314	+0·0395	4	42	12	48·52

No.	Decl. refer. to No. 25.	Prob. Error.	Yearly Precession. 1865·0.	Secul. Change.	Positions found by other Observers reduced to 1865·0. Mean R.A. h	m	s	Mean Decl. °	′	″
	″	″	″	″	h	m	s	°	′	″
1	+ 760·73	0·24	15·811	−0·350						
2	+ 831·43	·31	·806	·350						
3	+ 950·29	·46	·803	·350						
4	+ 433·81	·44	·793	·351						
5	+1251·25	·21	·792	·351						
6	+ 354·37	·41	·790	·351						

			Yearly Precession.		Positions found by other Observers reduced to 1865·0.		
No.	Decl. refer. to No 25.	Prob. Error.	1865·0	Secul. Change.	Mean R.A.	Mean Decl.	
	″	″	″	″	h m s	° ′ ″	
7	+ 995·65	0·13	15·785	−0·351	2 32 19·109	..	Argelander 1860·9
8	+ 817·87	·34	·784	·351			
9	+1120·51	·21	·782	·351	2 32 22·571	42 19 23·70	Argelander 1860·9
10	+1380·71	·42	·779	·351			
11	+ 259·62	·17	·777	·351			
12	+ 301·36	·30	·774	·351	2 32 32·076	42 5 37·16	Bessel 1831·9
13	+1442·00	·39	·772	·351			
14	+1387·22	·09	·771	·352			
15	+1394·27	·42	·769	·352			
16	+ 472·77	·36	·767	·352			
17	+1458·55	·41	·766	·352			
18	+1022·34	·24	·765	·352	2 32 40·856	...	Argelander 1860·9
19	+ 807·60	·26	·765	·352			
20	+1377·89	·43	·763	·352			
21	− 187·89	·48	·762	·352			
22	+ 806·70	·29	·762	·352			
23	+ 896·47	·22	·761	·352			
24	− 120·46	·35	·757	·352			
25	0·00	...	·754	·352	2 32 53·044 2 32 53·215	42 0 43·46 42 0 46·77	Bessel 1831·9 Fearnley 1865·1
26	+1482·54	·39	·749	·352			
27	+1029·59	·36	·748	·352			
28	+ 404·52	·22	·747	·352			
29	+ 643·53	·34	·746	·352			
30	+ 440·81	·33	·741	·353			
31	+ 640·73	·23	·740	·353			
32	+ 963·00	·31	·738	·353			
33	+1490·54	...	·735	·353	2 33 14·356 2 33 14·450	42 25 35·93 42 25 36·40	Arg. 1860·9 & 1861·1 Fearnley 1865·1
34	+ 288·38	·30	·734	·353			
35	+ 710·29	·28	·732	·353	2 33 17·070	42 12 30·98	Bessel 1831·9
36	+ 718·13	·32	·731	·353	2 33 18·358	42 12 38·44	Bessel 1831·9
37	+ 223·89	·20	·729	·353			
38	+ 561·80	·28	·728	·353			
39	− 277·24	·40	·727	·353			
40	− 165·05	·17	·725	·353			
41	+ 414·23	·18	·724	·353	2 33 26·236	42 7 36·10	Bessel 1831·9
42	+ 625·05	·34	·724	·353			
43	+ 865·57	·28	·721	·353			
44	+ 579·59	·45	·720	·354			
45	+ 701·40	·29	·719	·354			
46	+ 556·86	·31	·718	·354			
47	+ 386·20	·17	·718	·354			
48	+ 669·86	·21	·718	·354			

No.	Decl. refer. to No. 25.	Prob. Error.	Yearly Precession.		Positions found by other Observers reduced to 1865·0.		
			1865·0.	Secul. Change.	Mean R.A.	Mean Decl.	
	″	″	″	″	h m s	° ′ ″	
49	+ 105·17	0·18	15·717	−0·354			
50	+ 987·44	·40	·717	·354			
51	+ 1039·49	·38	·717	·354			
52	+ 1035·60	·41	·715	·354			
53	+ 34·24	·41	·714	·354			
54	+ 606·46	·34	·711	·354			
55	+ 30·70	·45	·708	·354			
56	+ 600·19	·24	·705	·354			
57	+ 34·37	·20	·703	·354			
58	+ 1370·20	·19	·702	·354			
59	+ 562·57	·35	·698	·354	2 33 55·136	42 0 43·89	Lalande 1790?
60	− 0·92	·10	·698	·354	2 33 56·066	42 0 46·96	Bessel 1831·9
61	+ 1159·90	·18	·697	·354	2 33 55·860	42 0 44·05	Fearnley 1865·1
62	+ 860·16	·44	·695	·355			
63	+ 840·92	·40	·690	·355			
64	+ 825·92	·20	·689	·355	2 34 3·600	42 14 29·69	Lalande 1790?
65	+ 391·33	·47	·688	·355			
66	+ 320·53	·30	·687	·355			
67	− 34·38	·27	·683	·355			
68	+ 481·56	·37	·683	·355			
69	+ 78·16	·21	·683	·355			
70	− 95·46	·47	·681	·355			
71	+ 821·61	·26	·679	·355			
72	+ 1097·46	·38	·677	·356			
73	+ 1515·36	·16	·675	·356	2 34 19·761 2 34 20·230	(42 25 57·43 computed) 42 26 1·20	Argelander 1861· Fearnley 1865·1
74	− 54·65	·43	·666	·356			
75	+ 55·08	·41	·663	·356			
76	+ 1304·16	·46	·662	·356			
77	+ 931·20	·19	·661	·356			
78	+ 720·93	·15	·659	·356			
79	+ 486·66	·45	·658	·356			
80	+ 660·53	·29	·653	·356			
81	+ 743·43	·20	·648	·357			
82	+ 114·75	·24	·646	·357	2 34 52·444	42 2 33·18	Bessel 1831·9
83	+ 643·78	·45	·638	·357			
84	+ 673·08	·42	·634	·357			
85	+ 723·05	0·27	15·622	−0·358			

A Rediscussion of the Observations of the Transit of Venus, 1769. By E. J. Stone, Esq.

Several methods of great refinement have been applied, within the last few years, to the determination of the fundamental unit of length of the Solar System,—the mean distance of the Sun from the Earth, or its equivalent, the mean horizontal equatorial parallax of the Sun. These investigations have all pointed to values about 8″·90. Each method appears to have its own inherent difficulty, but it is inconceivable that the systematic errors of each of these methods should tend to unduly increase the resulting value of the solar parallax. In opposition to the value 8″·90 we have that of 8″·58 deduced by Encke from the transits of *Venus* of 1761 and 1769. A transit of *Venus* has been considered, and I think justly considered, the most favourable of all our opportunities for the accurate determination of the solar parallax.

The observations made in 1769 were made, under generally favourable circumstances, by observers of experience. The places of observation were undoubtedly chosen with skill and judgment. The results have been discussed by an astronomer of acknowledged skill and ability. The discordance of the value thus deduced, by more than 0″·3 from the mean of the values determined, by at least three other independent methods, each entitled to great confidence, has naturally given rise to much anxiety and some doubt. It appeared to me that a new discussion of the observations made in 1769 must necessarily lead, if to nothing else, to a clearer view of the sources of systematic error, or wrong interpretation, which might be feared, and ought to be guarded against, in the observations proposed to be made at the Transits of 1874 and 1882.

I believe that my investigation has led me to the detection of several grave and fundamental errors, which have previously been made in the discussion of these results, and to a value of the solar parallax entitled to be received with confidence. From P. Hell's *Reise nach Wardoe bei Lappland und seine Beobachtung des Venus-Durchganges im Jahre* 1769, by Carl Ludwig Littrow. Wien, 1835, I extract the following:

Ingress.

"Internus autem limborum Solis et Veneris contactus Sole sat clare lucente, attamen aliquantulum limbo Solis et Veneris undulantibus observatus a me Tubo Dolondiano Haffniensi.

	H M S
Videtur contactus fieri	9 32 35
Contactus certus Visus	32 41
Fulmen	32 48

Pater Sajnovics suo tubo

Contactus dubius	9 32 30	30
Certissimus ut ajebat	9 32 45	45

Idem obtinuit D. Borgrewing secunda nempe — 10″—post numerata minuta, sed loco 32 minutorum mihi exhibuit 33′.

Egress.

Ego tubo meo ad idem Horologium

	H	M	S
Videtur aliqua gutta nigra intra limbum Solis et Veneris ante contactum formari ..	15	26	6
gutta hæc minui videtur valde		26	12
Disparet, et contactum fieri censeo		26	17
Certissimus contactus		26	19

Pater Sajnovics.

Contactus dubius certus	15	26	18
Certus			26
D. Borgrewing	15	26	10

Some alterations and additions to the Journal made in darker ink, are indicated by bolder writing. They appear to be chiefly in the order of arrangement and explanation. Fulmen 32 48, appears alone in the darker ink.

It will be seen that at the egress Father Hell makes a distinction between the forming of the black drop and the contact. It has been previously assumed that at the ingress "contactus certus visus," refers to the breaking of the black drop, although we have the phrase, "Disparet, et contactum fieri censeo," &c., referring to the actual contact of the limbs at the egress. This false interpretation is at the very root of the discussion, and an error here leads to nothing but confusion. I shall assume, and I think there will be no further doubt upon this point, that the same phrases must be similarly interpreted at the ingress and egress. Therefore, taking the means of "dubius certus" and "certus" as the true time of contact, I have

Ingress.

	Contact of Limbs.	Reduction to true M.T.
	h m s	m s
Hell's observation	9 32 38	− 1 1·8
Sajnovics'	9 32 37·5	− 1 1·8

Hence, in Paris Mean Time, we have,

	h m s
Hell's observations	9 31 36·2
Sajnovics'	9 31 35·7

I believe it probable that the minutes given by Borgrewing are right, and that he really tried to observe the breaking of the black drop. This, however, is doubtful, and I shall not use the observation.

Egress.

	Contact of Limbs.	Correction to M.T.
	h m s	s
Hell's observation	15 26 18·0	− 59·6
Sajnovics'	15 26 22·0	− 59·6
D. Borgrewing	15 26 10	

Or, in Paris Mean Time,

	h m s
Hell's observation	15 25 18·4
Sajnovics'	15 25 22·4

Since Borgrewing's corresponding observation at ingress is lost, I shall not use his observation at egress. Its use would not, however, change my result. I adopt, therefore, the following observed durations from internal contact to internal contact at Wardhus:—

	h m s
From Hell's observations	5 53 42·2
From Sajnovics'	5 53 46·7

I would also call attention to Father Hell's difference at egress between the formation of the black drop and contact of the limbs, viz. 12^{s}.

Kola.

The observations at this station were made under unfavourable circumstances. I shall adopt the same data as Encke. The phase is that from the breaking to the formation of the black drop. Encke places the observations in the second class. I shall give it a weight one-half that of the other observations. It is, however, very exactly represented by my result.

Observations at Hudson's Bay by W. Wales and Dymond. Extracted from the *Phil. Trans.* 1769.

	Apparent Time.	
	h m s	
Exterior contact at the ingress	0 57 0·6	J.D.
	0 57 7·6	W.W.
Interior ditto	1 15 21·3	W.W.
	1 15 25·3	J.D.
The thread of light broke at the internal contact	7 0 45·5	W.W.
	7 0 48·5	J.D.
External contact	7 19 1·25 }*	W.W.
	7 19 20·25	J.D.

* Very hazy, and the limbs badly defined.

Remarks.

(3) The heavens at the beginning, and for a considerable time, both before and after, were frequently obscured by clouds, but, in the intervals, the air was very clear, and the Sun's limbs extremely well defined.

(4) Soon after *Venus* was half immerged, a bright crescent, or rim of light, encompassed all that part of her circumference which was off the Sun, thereby rendering her whole periphery visible. This continued very bright until within a few minutes of the internal contact, and then vanished away gradually.

(5) We took for the instant of the first internal contact the time when the least visible thread of light appeared behind the subsequent limb of *Venus*, but before that time *Venus*' limb seemed within that of the Sun, and his limb appeared behind hers in two very oblique points, seeming as if they would run together in a broad stream, like two drops of oil, but which, nevertheless, did not happen, but joined in a very fine thread, at some distance from the exterior limb of *Venus*. This appearance was much more considerable at the egress than at the ingress, owing, as we apprehend, to the bad state of the air at the time. We took for the instant of internal contact, at the egress, the time when the thread of light disappeared before the preceding limb of the planet, from which time W.W. took notice that he had told about 24^s when the limbs of the Sun and *Venus* were apparently in contact; a circumstance which he did not venture to attend to at the egress.

(6) Nothing like an atmosphere (except the above-mentioned phenomena); no satellite observed.

(7) The haziness at egress arose from the usual state of the atmosphere, 10° or 12° above the horizon.

The observations of Wales and Dymond refer to the time of the breaking and formation of the black drop. Wales estimates the interval between the forming of the black drop at egress and the contact of the limbs at 24^s. These observations are clearly not comparable with those made at Wardhus, except allowance be made for the difference of phase observed.

St. Joseph.

The observers at and near this station were Chappe, Pauly, Vicente Doz, and Salvador Medina. I cannot find any details of the observations of Vicente Doz and Salvador Medina, but their results agree so closely with those of Chappe that the observations evidently refer to the same phases of the phenomena.

Extract from "*Voyage en Californe pour l'Observation du Passage de Vénus sur le disque du Soleil, le 3 Juin*, 1769. Par M. Chappe." Paris, 1772.

	Temps observé à la pendule.	Temps Vrai.
	h ′ ″	h ′ ″ ‴
2 Juin	23 57 32	23 59 17 2

à la lunette achromatique de 3 pieds.

"*Note.*—J' apperçois *Vénus* faisant une petite échancrure sur le bord du Soleil parfaitement terminé. Je ne crois pas que cette

Première phase s'écarte beaucoup de la véritable, parceque l'échancrure étoit très petite.

		h ′ ″
3 Juin	0 3 30	0 5 15·0

"Entrée du centre, estimée. Je fus très attentif à examiner si je verrois *Vénus* hors du Soleil, avec le croissant qui a été vu dans le passage de 1761 ; mais je ne l'apperçus pas. Je remarquai seulement que vers le milieu de l'entrée de cette planète on distinguoit une partie du disque de *Vénus* proche du disque du Soleil, tel qu'on le voit dans la figure première, planche troisième. Les deux corners, A et B, ou continuation du disque de *Vénus*; sembloient à la vérité annoncer le commencement du croissant que je n'aurai peut-être pas apperçu à cause que ma lunette groississoit beaucoup et étoit par conséquent, moins claire.

Observé.	Temps Vrai.	
h ′ ″	h ′ ″ ‴	
0 15 42	0 17 26 52½	Second contact.

" A l'entrée totale de *Vénus* j'observai très distinctement le second phénomène qui avoit été remarqué par la plus grande partie des astronomes en 1761. Le bord du disque de *Vénus* s'alongea (voy. figure 2). Comme s'il étoit attiré par le bord du Soleil. Je n'observai point pour l'instant de l'entrée totale, celui où le bord de *Vénus* commençoit à s'alonger ; mais ne pouvant pas douter que ce point noir ne fit partie du corps opaque de *Vénus*, j'observai le moment où il étoit à sa fin ; de façon que l'entrée totale ne peut être arrivée plutôt, mais peut-être plus tard de deux ou trois secondes. Le point noir étoit un peu moins obscur que le reste de *Vénus*. Je crois que c'est le même phénomène que celui que j'observai à Tobolsk en 1761.

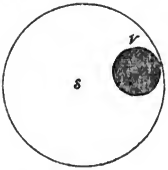


Fig. 2.

Temps observé à la pendule.	Temps Vrai.
h ′ ″	h ′ ″ ‴
5 53 9	5 54 50 8⅔

Premier contact à la sortie, *avec la lunette de dix pieds* (not the same telescope). Le Soleil étoit ondoyant ainsi que *Vénus*, ce qui rendoit cette observation très difficile. A ce premier contact

Venus s'est alongée plus considérablement que le matin, en s'approchant tout-à-coup du bord du Soleil.

$6^{h}\ 2'\ 16''$ $\qquad$ $6^{h}\ 3'\ 57''\ 12\tfrac{1}{3}'''$

Sortie du centre estimée très exactement à ce qu'il m'a paru.

$6^{h}\ 11'\ 38''$ $\qquad$ $6^{h}\ 13'\ 19''\ 7\tfrac{1}{2}'''$

Second contact ou sortie totale. Elle ne me paroît pas être arrivée plutôt peut-être 4^{s} plus tard, mais je n'en suis pas certain.

"Pour observer avec toute la précision possible les deux contacts à la sortie, je disposai ma lunette de façon que je ne fusse pas obligé de la remuer vers ces moments. Sans cette précaution j'eusse été dans le cas de perdre de vue *Vénus;* de prendre le fond du ciel pour le bord du disque de cette planète, et de commettre ainsi une erreur énorme, au lieu qu'en ne quittant pas un instant de vue, au dernier contact, le bord de *Vénus* que paroissoit un peu plus noir que le fond du ciel, j'eus cette phase avec toute l'exactitude possible.

"J'avois chargé M. Pauly d'observer à la lunette de trois pieds les deux contacts de la sortie; il étoit déja un peu exercé au observations. Il observa le premier contact 22^{s} plutôt que moi et le dernier 37^{s} plutôt. Comme il étoit à côté de moi, je m'apperçus du moment où il quitta la lunette pour aller à la pendule et je vis très bien qu'il fixoit trop tôt les moments du premier et du second contact, car je voyois encore *Vénus* parfaitement lorsqu'il étoit à la pendule."

It is clear from Chappe's account that at the ingress he observed the breaking of the black drop. I have given the figure 2 for comparison with corresponding figures at Otaheite.

I consider, from the description given by Chappe himself, that at the egress he did not catch the formation of the black drop. He appears to have been surprised by the contact being established all at once. This view is materially strengthened by the observation of Pauly, who gives a contact 22^{s} earlier than that of Chappe. This observation of Pauly is clearly an observation of the formation of the black drop.

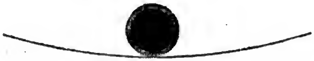
Observations made at King George's Island, in the South Sea, by Mr. Charles Green, formerly assistant at the Royal Observatory, Greenwich, and Lieut. James Cook, of H.M.S. *Endeavour. Phil. Trans.* 1771.

The telescopes employed in making the observations were, two reflecting telescopes of two feet focus each, made by the late Mr. James Short.

Transit of *Venus* by Mr. Green; magnifying power, 140.

	App. time.		
	h	m	s
First internal contact of ♀'s limb and the ☉, see fig. 4, (June 2)	21	43	15
Penumbra and ☉'s limb in contact, see fig. 5	21	43	55
First contact of penumbra, undulating, but the thread of light visible and invisible alternately (June 3)	3	14	3
Second internal contact of the bodies	3	14	51

Fig. 5.



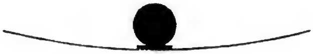
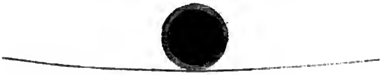


Fig. 4.

Observations of Cook; magnifying power, 140.

	h	m	s
First internal contact, or the limb of ♀ seemed to coincide with the ☉'s, fig. 2	21	43	15
A small thread of light seen below the penumbra, fig. 3	21	44	15
Second internal contact of the penumbra, or the thread of light wholly broken..	3	14	13
Second internal contact of the bodies, and appeared as in the first	3	14	45

Fig. 3.



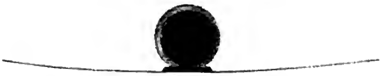


Fig. 2.

Dr. Solander's observations.

	h	m	s
Ingress, light seen glimmering under ♀	21	43	28
♀'s free from the ☉'s limb	21	44	2
♀'s true limb out	3	31	49
♀'s atmosphere out	3	32	13

I shall not use Solander's observations. He has not observed the internal contact or breaking of black drop at egress: the time at ingress 21 44·2 falls between the two observations of Green and Cook, and its introduction would not therefore modify sensibly my result. There appears here a real difficulty in exactly understanding the phenomena observed by Green and Cook. I append Cook's remarks upon these observations.

"The first appearance of *Venus* on the Sun, was certainly only a penumbra, and the contact of the limbs did not happen till several seconds after, and then it appeared as in figure 4 (not given); this appearance was observed both by Mr. Green and me; but the time it happened was not noted by either of us: it appeared to be very difficult to judge precisely of the times that the internal contacts of the body of *Venus* happened, by reason of the *darkness of the penumbra at the Sun's limb, it being there nearly, if not quite, as dark as the planet.* At this time a faint light, much weaker than the rest of the penumbra, appeared to converge towards the point of contact, but did not quite reach it, see fig. 2. This was seen by myself and the two other observers, and was of great assistance to us in judging of the time of the internal contacts of the dark body of *Venus* with the Sun's limb. Fig. 5 (not given) is a representation of the appearance of *Venus* at the middle of the egress and ingress, for the very same phenomenon was observed at both: at the total ingress, the thread of light made its appearance with an uncertainty of several seconds; I judged that the penumbra was in contact with the Sun's limb 10″ sooner than the time set down above; in like manner at the egress the thread of light was not broke off or diminished at once, but gradually, with the same uncertainty: the time noted was when the thread of light was wholly broke by the penumbra."

It appears to me clear that the penumbra, *as dark or nearly as dark as the planet,* is nothing more nor less than a part of the planet itself. If this be so, Cook and Green have both observed contacts, and not the forming and breaking of the black drop. Cook states that at the egress he observed the time when the thread of light was wholly broken off by the penumbra.

I shall assume in my investigation that internal contacts were observed.

It now remains to form the equations of condition. $d\alpha$, $d\Delta$ denote the relative Tabular errors of *Venus* and the *Sun* in R.A. and N.P.D. $d\varpi$ the correction required to the assumed value of solar parallax $8''\cdot49$, ϱ, ϱ' the corrections required by Encke's assumed semidiameter of *Venus* corresponding respectively to an internal contact and the formation or breaking of the black drop.

$$x = 6\cdot57\,d\alpha + 24\cdot45\,d\Delta + 39\cdot71\,\varrho$$

$$y = 6\cdot57\,d\alpha + 24\cdot45\,d\Delta + 39\cdot71\,\varrho^{1}$$

Then $\frac{x-y}{2}$ = interval between the internal contact and breaking or forming of the black drop.

Wardhus.

The observations made use are of the internal contacts observed by Hell and Sajnovics.

Ingress.

Observer.	
Hell	$10{\cdot}237\,d\alpha - 16{\cdot}236\,d\Delta - 44{\cdot}50\,d\varpi - 19{\cdot}658\,\rho = -34^{s}{\cdot}8$
Sajnovics	$10{\cdot}237\,d\alpha - 16{\cdot}236\,d\Delta - 44{\cdot}50\,d\varpi - 19{\cdot}658\,\rho = -35^{s}{\cdot}3$

Egress.

Observer.	
Hell	$16{\cdot}538\,d\alpha + 8{\cdot}135\,d\Delta + 30{\cdot}84\,d\varpi] + 19{\cdot}658\,\rho = +18^{s}{\cdot}6$
Sajnovics	$16{\cdot}538\,d\alpha + 8{\cdot}135\,d\Delta + 30{\cdot}84\,d\varpi + 19{\cdot}658\,\rho = +22^{s}{\cdot}6$

For the durations we have sensibly

		Observer.
(1)	$x + 75{\cdot}34\,d\varpi = +53{\cdot}4$	Hell.
(2)	$x + 75{\cdot}34\,d\varpi = +57{\cdot}9$	Sajnovics.

Hell's observation at egress gives 12^{s} between the formation of the drop and internal contact.

Kola.

The observation here is from the breaking to the formation of the drop. The weight given to this equation will only be one half.

(3)	$y + 76{\cdot}63\,d\varpi = +21{\cdot}6$	Rumovsky.

Hudson's Bay.

The observations here are from the breaking to the formation of the black drop.

(4)	$y + 23{\cdot}59\,d\varpi = +0{\cdot}5$	Wales.
(5)	$y + 23{\cdot}59\,d\varpi = -0{\cdot}5$	Dymond.

St. Joseph.

The observations here are mixed.

Ingress.

Observer.						
Chappe	$10{\cdot}03\,d\alpha$	$-\,16{\cdot}78\,d\Delta$	$-\,2{\cdot}01\,d\varpi$	$-\,19{\cdot}941\,\rho^{1}$		$= +3{\cdot}6$
V. Doz	,,	,,	,,	,,	,,	$= +1{\cdot}8$
Medina	,,	,,	,,	,,	,,	$= +6{\cdot}8$

Egress.

Observer.						
Chappe	$16{\cdot}64\,d\alpha$	$+\,8{\cdot}78\,d\Delta$	$-\,33{\cdot}31\,d\varpi$	$+\,19.941\,\rho$		$= -2{\cdot}3$
V. Doz	,,	,,	,,	,,	,,	$= -5{\cdot}0$
Medina	,,	,,	,,	,,	,,	$= -5{\cdot}0$

For durations we have—

		Observer.
(6)	$\frac{x+y}{2} - 31\cdot30\,d\varpi = -\ 5\cdot9$	Chappe.
(7)	$\frac{x+y}{2} - 31\cdot30\,d\varpi = -\ 6\cdot8$	V. Doz.
(8)	$\frac{x+y}{2} - 31\cdot30\,d\varpi = -\ 11\cdot8$	Medina.

Pauly at this station observed the formation of the black drop 22^s before Chappe observed the internal contact.

Otaheite.

The observations here are from internal contact to internal contact.

		Observer.
(9)	$x - 83\cdot40\,d\varpi = -\ 5\cdot9$	Green.
(10)	$x - 83\cdot40\,d\varpi = -\ 15\cdot9$	Cook.

Multiplying all the equations except the Kola equation by 2, and reducing the 10 equations by the method of least squares, I find the following equations for the determination of x, y, and $d\,\Pi$.

$$\begin{aligned} 19\,x + 3\,y - 252\cdot28\,d\varpi &= +\ 309\cdot0 \\ 3\,x + 12\,y + 48\cdot10\,d\varpi &= -\ 27\cdot4 \\ -\ 252\cdot28\,x + 48\cdot10\,y + 123133\cdot75\,d\varpi &= 45536\cdot46 \end{aligned}$$

$$\therefore \quad 119113\,d\varpi = 50220\cdot58$$

$$d\varpi = 0''\cdot421$$

$$\text{or} \quad \varpi = 8''\cdot91 \pm 0\cdot008\,\epsilon$$

$$x = 23^s\cdot4$$

$$y = -\ 9\cdot8$$

$$\frac{x-y}{2} = 16^s\cdot6$$

ϵ is the probable error of a single observation of contact.

If $\epsilon = 3^s$ the probable error of ϖ is $0''\cdot02$.

The mean of the three results, 24^s, 22^s, 12^s, for the difference between the internal contact and breaking of the black drop is 19^s. The value of $\frac{x-y}{2}$ resulting from the equations of condition is therefore satisfactory.

It will be seen from the following table that the observed durations are all represented in a satisfactory manner.

I may here mention that the satisfactory solution of these equations in the way which has previously been virtually attempted by assuming $x = y$ is impossible. Of course by rejecting the observations at different stations, different results could be thus obtained, and any required value of the parallax within wide limits thus obtained.

The discordances between the computed and observed durations are reduced as follows,—

Observer.	s		s		Mean Error. s
Hell	53·4	to	− 1·7	Wardhus.	+ 0·6
Sajnovics	57·9	to	+ 2·8		
Wales	+ 0·5	to	+ 0·4	Hudson's Bay	− 0·1
Dymond	− 0·5	to	− 0·6		
	+ 21·6	to	− 0·9	Kola.	− 0·9
Chappe	− 5·9	to	+ 0·5	St. Joseph.	− 1·6
V. Doz	− 6·8	to	− 0·4		
Medina	− 11·8	to	− 5·4		
Green	− 5·9	to	+ 5·8	Otaheite.	+ 0·8
Cook	− 15·9	to	− 4·2		

I consider therefore that, by simply interpreting strictly the language employed by the observers, I have been led to a solution which satisfies the whole of the ten observed durations, and gives at the same time, from the equations of condition, a satisfactory result for the difference between the time of internal contact and the breaking of the black drop. The value of deduced solar parallax 8″·91 appears to me therefore entitled to great weight. It is in most satisfactory agreement with the values which have lately been otherwise obtained. I do not consider the incomplete observations of ingress, and particularly of egress, sufficiently numerous and well distributed to afford, by their combination with the observations here made use of, satisfactory determinations of $d\,\alpha\;d\,\Delta\;\varrho\;\varrho'$, and to give, at the same time, a value of $d\,\Pi$ entitled to more, or even to equal confidence to that obtained from the durations. A great number of these observations were made under unfavourable circumstances, and the errors of observation as shown by their discordances are large. In addition to the mere errors of observation, we have, in the discussion of these imperfect observations, the full errors of assumed longitudes coming into the equations of conditions, and also errors of judgment in selecting the phase of the phenomenon of the transit of *Venus* really attempted to be caught by the observer.

I shall merely state, in conclusion, that I have not alluded to Powalky's discussion, because I consider that far too great license has been allowed the judgment in the selection of the materials to be used. Several of the results well represented in my equations are rejected as erroneous by him. If the necessity of separating the phenomena observed, in the way I have done, be admitted, no reliance can of course be placed upon any result obtained without such separation. The data are, in fact, inconsistent, and nothing but confusion could result from the mere application of least squares.

Blackheath, 1868, Sept. 23.

On the Variability of η Argûs. By J. Tebbutt, Jun. Esq.

In the *R. A. S. Monthly Notices* for January 1866, was published a series of comparisons of *η Argûs*, made by me with neighbouring stars from 1854 to the middle of March 1865. A marked diminution of the star's light has taken place since that period, it being at present hardly distinguishable to the naked eye, even by oblique vision. I now forward a series of careful comparisons made since March 1865.

Comparisons.

1866, Feb. 16. Sky brilliantly clear. *η Argûs* was considerably less than B. A. C. 3655 or 3688.

1866, March 22. Sky very clear in the neighbourhood of *η Argûs*. Less than B. A. C. 3655 or 3688.

1866, June 29, 6^h 15^m P.M. Sky very clear, but *η Argûs* hardly distinguishable. Much less than B. A. C. 3655 or 3688.

1866, July 4, 6^h 45^m P.M. Sky beautifully clear, and the *Via Lactea* very distinct. *η Argûs* was much less than B. A. C. 3655 or 3688, and even less than B. A. C. 3642. It could be distinguished only by oblique vision; B. A. C. 3680 and 3673 could not be distinguished at all with the naked eye.

1866, Dec. 3, 10^h 20^m P.M. Scarcely distinguishable, and was very much less than B. A. C. 3655 or 3688.

1866, Dec. 8. Midnight. Sky beautifully clear, and the stars at a great altitude. *η Argûs* was very much less than B. A. C. 3655 or 3688. It was seen as a distinct stellar point in the nebula by oblique vision. It might be considered about equal, or perhaps superior, to B. A. C. 3642, the latter being seen by oblique vision.

All the foregoing comparisons were made with the naked eye.

1866, Dec. 11, 11^h P.M. By means of a small telescope, *η Argûs* was estimated to be brighter than B. A. C. 3673, and perhaps slightly inferior to B. A. C. 3642 or 3680.

The following comparisons, except those on May 4, 1867, and April 13 and 22, 1868, were made with a telescope of 3½ inches aperture, and a magnifying power of about 30.

1866, Dec. 12, 11^h P.M. B. A. C. 3655, a light orange-coloured star, was considerably the brightest in the field of the telescope; is had a very small companion on the north side. B. A. C. 3642 and 3680 were the next in order of brightness, and appeared to be about equal; B.A.C. 3648 next; then *η Argûs*, which about equal to B.A.C. 3657. B.A.C. 3673 was less than *η Argûs.* The magnitude of *η Argûs* by a very careful examination was intermediate between those of B.A.C. 3648 and 3673, and about equidistant between B.A.C. 3673 and 3680. The stars and nebula were beautifully distinct. There are no stars in the catalogued positions of B.A.C. 3679 and 3683.

1867, Jan. 12. Of *η Argûs*, B.A.C. 3655, 3680, and 3673, B.A.C. 3655 was much the brightest; *η Argûs* and 3680 were nearly equal; but 3680 decidedly the brighter, and 3673 the least of all. The comparisons were made between $9^h\ 30^m$ and $9^h\ 45^m$ P.M.; the stars being beautifully distinct; but the Moon about five days old in the west.

1867, Jan. 26, $8^h\ 20^m$ P.M. Beautifully clear night, and the Moon absent. Of the stars mentioned in the comparisons for Jan. 12, B.A.C. 3655 was the brightest, and *η Argûs* was greater than B.A.C. 3673 and less than B.A.C. 3680.

1867, March 2, $9^h\ 15^m$ P.M. Of the stars B.A.C. 3655, 3680, 3673, and *η Argûs*, the first was the brightest, *η Argûs* ranging between B.A.C. 3680 and 3673, but approximately to B.A.C. 3680. The night was beautifully clear, the Moon absent, and the stars at a great altitude.

1867, April 17, $6^h\ 40^m$ P.M. Clear sky, but Moon near the opposition. *η Argûs* was considerably brighter than B.A.C. 3673 and slightly inferior to B.A.C. 3680.

1867, May 4. B.A.C. 3680 less than B.A.C. 3655, and *η Argûs* less than B.A.C. 3680, and greater than B.A.C. 3673. The comparisons were made while the stars were crossing the field of the transit telescope.

1867, July 27, $9^h\ 25^m$ P.M. Beautifully clear sky, and the nebula about *η Argûs* very distinct. Of the stars B.A.C. 3655, 3680, *η Argûs*, and B.A.C. 3673, 3655 was the brightest; 3680 next; *η Argûs* next; and 3673 the least. The magnitude of *η Argûs* was nearer that of 3680 than that of 3673.

1867, Dec. 28. Sky beautifully clear. Of the compared stars, B.A.C. 3655 was by far the brightest; B.A.C. 3680 the next; *η Argûs* the next; and B.A.C. 3673 the least. The inferiority of *η Argûs* to B.A.C. 3680 was marked; but it was not much superior to B.A.C. 3673.

1867, Dec. 31. Of the compared stars, B.A.C. 3655 was the brightest, and *η Argûs* was certainly less than B.A.C. 3680, and somewhat greater than B.A.C. 3673. The comparisons were made about half an hour after midnight, the stars being at a great altitude.

1868, Feb. 26, $7^h\ 45^m$ P.M. Sky beautifully clear, and the Moon just set. Of the compared stars, B.A.C. 3655 was the brightest; *η Argûs* ranged between B.A.C. 3680 and 3673, but approximated to 3680.

1868, Feb. 27, $8^h\ 45^m$ P.M. Sky cloudless, and the nebula very distinct. *η Argûs* was compared with B.A.C. 3655, 3673, and 3680. B. A. C. 3655 was the brightest of the four. *η Argûs* was greater than 3673, and less than 3680.

1868, April 13. B. A. C. 3642, 3655, 3673, 3680, and *η Argûs* were compared as they crossed the field of the transit telescope, both with and without illumination; the power employed being 25. The last four stars were compared at one view, B.A.C. 3642 having shortly before quitted the field. 3642 was not so bright as 3655. 3655 was much brighter than 3680. 3680 considerably brighter than *η Argûs*, and *η Argûs* slightly superior to 3673. The superiority of B. A. C. 3680 to *η Argûs* was very marked.

1868, April 22. The following comparisons were made in the field of the transit telescope, both with and without illumination. Of the compared stars, B. A. C. 3655 was by far the brightest. *η Argûs* was greater than B. A. C. 3673 and less than B. A. C. 3680. The inferiority of *η Argûs* to 3680, and its superiority to 3673, were marked.

It is obvious from these observations that *η Argûs*, during 1867 and the elapsed portion of the present year, has not exceeded the *sixth* magnitude. It does not appear, therefore, that the present variations of this star are reconcileable with the theory of Professor Wolf, in the *Monthly Notices* for May 1863, and the *Ast. Nach.* No. 1420, which gives 1861 and 3·6 respectively, as the time and magnitude for the minimum.

Windsor, New South Wales, April 29th, 1868.

Observations of a Minor Planet discovered by Prof. C.J. Watson at Ann Arbor Observatory, 1868, July 11.

	Ann Arbor M.T.	R.A.	Decl.
	h m s	h m s	° ′ ″
1868, July 11	13 36 14·7	21 10 54·40	−15 47 45·4
	15 16 47·9	21 10 52·28	−15 48 4·3
13	12 2 19·9	21 9 53·43	−15 57 24·9

The planet resembles a star of the 11th magnitude.

This planet appears to be the same as that independently discovered by M. Coggia on July 16. E. J. S.

The Astronomische Gesellschaft.

Two biennial meetings have been held of the Astronomische Gesellschaft, the first at Leipzic, from August 31 to September 2, 1865, the second at Bonn, from August 22 to 24, 1867, both under the Presidency of Prof. Argelander. Among the subjects discussed at the meeting of 1867 are—

1. The Construction of New Tables of *Jupiter*. It appeared from communications received from MM. Hansen and Leverrier that both of these Astronomers were in fact occupied with the question, and thus that no action of the Society was requisite.

2. A new reduction of the older observations of the Periodic Comets had been in discussion at the Leipzic meeting. Four points had been specified—the new determination of the places of the stars of comparison, the calculation of the auxiliary quantities with the now-received values of the constants for the times of the appearance of the comets, the calculation of solar ephemerides for these times, lastly, the publication of the originals of the older comet observations.

As to the first point, Prof. Argelander had, in all the necessary cases, redetermined at the Bonn Observatory the places of the stars of comparison as collected by Prof. Schönfeld, and had published the new places in the sixth volume of the Bonn Observations.

As to the second point, it was hoped that the New Tables of Bessel's Auxiliary Quantities for the whole period 1750 to 1839, in continuation of the "Tabulæ Pulcovenses," beginning in 1840, would be published: this, however, was not undertaken by the Society, partly in consequence of it being known that some portions of the work had been accomplished or were in progress in America.

As to the third point, nothing has been done.

As to the fourth, some progress had been made by Prof. Argelander, who however mentioned that, for instance, the originals of the important observations of Triesnecker were not to be found, and that those of Olbers were not so perfect as to allow of a complete fresh reduction; it would be necessary in many cases to rest contented with the distances of comet and star as determined by Olbers himself.

Prof. Argelander remarked that he had been equally unsuccessful in discovering the original observations of Variable stars; those, for instance, of Pigott, Goodricke, and Koch, seemed to be quite lost.

It appeared that the calculations for the comets of Encke, Faye, Brorsen, D'Arrest, and Tuttle, were being proceeded with; but a list of thirty-one comets from 1830 to 1867 was given, which remained for further discussion. And a wish was expressed that Astronomers who were occupying themselves with any particular comets, or appearances thereof, would put themselves in communication with the Society.

M. von Struve expressed the like wish as to information being given to him at Pulkova in regard to any discussions of Double stars.

3. The need of a new reduction of Bradley's observations had been noticed as well at the foundation of the Society at Heidelberg, as at the Leipzic meeting. This however was not so much the concern of the Society as of the Pulkova Observatory, which

had received from Greenwich a carefully-compared copy of the Observation-Journals from 1750 to 1765, and of the other Bradley manuscripts; the work, in consequence of the illness of Dr. Winnecke, had been undertaken by Dr. Auwers.

4. A scheme by Prof. Schönfeld for the nomenclature of Variable stars was discussed.

5. A programme was received for the observation of all the stars up to the ninth magnitude between —2° and +80° declination. The co-operation of Astronomers was invited; the Observatories which had offered to take part in the work were Berlin, Bonn, Helsingfors, Leipzig, Mannheim, and (after the completion of some work in hand) Leyden.

6. A discussion took place, and some resolutions were adopted, as to the nomenclature of Comets and Minor Planets.

The next meeting was appointed to be at Vienna in the year 1869.

Besides the *Vierteljahrsschrift*, or Quarterly Journal of the Society, the following works have been published by them:—

I. Hülfstafeln zur Berechnung specieller Störungen, enthaltend die rechtwinkligen Ecliptical-Coordinaten und die von Orte des gestörten Körpers unabhängigen Theile der Störenden Kräfte fur die Planeten Venus, Erde, Mars, Jupiter, Saturn, Uranus, und Neptun, von 1830–1864. 1865.

II. Lesser, Dr. Otto. Tafeln der Metis mit Berücksichtigung der Störungen durch Jupiter und Saturn. 1865.

III. Weiler, Dr. A. Ueber das Problem der drei Körper im Allgemeinen und ins Besondere in seiner Anwendung auf die Theorie des Mondes.

IV. Hoüel, Dr. G. J. Tables pour la reduction du temps en parties décimales du jour. 1866.

V. Auwers, Arth. Reduction der Beobachtungen der Fundamental-Sterne am Passage-instrument der Sternwarte zu Palermo in den Jahren, 1803–1805, und Bestimmung der mittleren Recht-Ascensionen für 1805. 1866.

VI. Rechtwinkelige und Polar co-ordinaten des Jupiter (nach Bouvard's Tafeln) sowie Componenten der störenden Kräfte mit denen Jupiter auf die Sonne wirkt von 1770–1836. 1866.

VII. Anwers, Arth. Untersuchungen über verändeliche Eigenbewegungen. Zweiter Theil. Bestimmung der Elemente der Siriusbahn.

VIII. Schjellerup, genaherte Oerter der Fixsterne von welchen in den Astronomischen Nachrichten Band 1–66 selbststandige Beobachtungen angefuhrt sind, für die Epoche 1855 hergeleitet und nach den geraden Aufsteigungen geordnet. 1867.

Recent Publications.

Descriptive Astronomy, by George F. Chambers, F.R.A.S. Oxford, Clarendon Press, 1867, 8vo, pp. ix. to xxxvii. and 1 to 816.

The work appears to answer in a high degree to the author's idea of making it at once attractive to the general reader, serviceable to the student, and handy for the purposes of reference to the professional Astronomer. The arrangement of the subject is in the ten books:—The Sun and Planets, Eclipses and their Associated Phenomena, Physical and Miscellaneous Astronomical Phenomena, Comets, Chronological Astronomy, the Starry Heavens, Practical Astronomy, Sketch of the History of Astronomy, Meteoric Astronomy, and Astronomical Tables. Great pains appear to have been used in the collection and selection of the information, and in bringing it up to the latest period; and at the same time that the whole is in a very readable form, the facts are very frequently presented, as is obviously most convenient, in a tabular form: for instance, the history of particular discoveries or researches is given (often very completely) in the natural place in connexion with the celestial object to which they refer, but the short book of 21 pages, "Sketch of the History of Astronomy," is in fact a chronological table of Astronomers, occurrences, and discoveries. A valuable chapter on Celestial Photography and a Catalogue of Binary Stars are contributed to the work by Mr. A. Brothers. There are in all 224 illustrations; as to those of Clusters and Nebulæ, the author remarks that they are not at all to his satisfaction, there being the usual difficulty of preventing the undue exaggeration of the brilliancy of the stellar details.

Theoretical Astronomy, relating to the Motions of the Heavenly Bodies revolving around the Sun, in accordance with the Law of Universal Gravitation, embracing a Systematic derivation of the Formulæ for the Calculation of the Geocentric and Heliocentric places, for the determination of the Orbits of Planets and Comets, for the Correction of approximate elements, and for the computation of Special Perturbations; together with the theory of the combination of Observations and the method of Least Squares. By James C. Watson, Director of the Observatory at Ann Arbor, and Professor of Astronomy in the University of Michigan. London: Trübner and Co.

The somewhat long title of this remarkable and laborious work gives a general idea of its contents. The book commences with the fundamental principles of dynamics and treats systematically all the problems presented; the author hoping in this way to aid the progress of the Science by attracting into the field and educating competent computers. Numerical examples are given, derived from actual observations and the tables which accompany the work are of great value.

M. Hoek has communicated to the Editor the following list of Errata in the paper on "The Phenomena of Meteors."

Page	Line	
132	10	W *should be* W_2.
132	last line	$\sqrt{A^2 + s}$, *should be* $\sqrt{A^2 + s^2}$.
133	3	$e = 0$ *should be* $e = 1$.
134	12	$x_2 = \mp\sqrt{A(1 + \cos B)}$, *should be* $x_2 = \mp\sqrt{\frac{1}{2}A(1 - \cos B)}$.
136	4	$\frac{p + x}{g}$ *should be* $\frac{p + x}{y}$.
136	7	$\frac{dy}{\sin\frac{1}{2}n}$ *should be* $\frac{dq}{\sin\frac{1}{2}n}$.
137	14	$R = 1$ *should be* $r = 1$.
138	table of values of D	27° 7′ *should be* 27·7.
139	1	V *should be* U.
142	second form (40)	$2\cos\frac{1}{2}\cos H$ *should be* $2\cos\frac{1}{2}n\cos H$.
142	20	$U = B_1$ *should be* $U = B$.
143	Table	Sept. 4 *should be* Sept. 5.
143	last line	0·00879 *should be* 0·000879.
144	4	angular *should be* relative.
144	9	point R_1 *should be* point R.
148	20	observed *s* *should be* adopted *s*.
148	25	$\frac{g}{V^2} = 0{\cdot}3809$ *should be* 0·4217.
148	29	31° 15′ *should be* 31° 51′.

CONTENTS.

Page

The Total Solar Eclipse of August 17–18, 1868, by Maj. Tennant ... 245

On the Cluster in *Perseus*, by Dr. Pihl 246

A Rediscussion of the Observations of the Transit of *Venus*, by Mr. Stone 255

On the Variability of *η Argûs*, by Mr. Tebbutt 266

Observations of a Minor Planet discovered by Prof. J. C. Watson, at Ann Arbor Observatory, 1868, July 11 268

The Astronomische Gesellschaft ... ... ib.

Recent Publications 271

Errata in M. Hoek's paper on "The Phenomena of Meteors" 272

Index 274

INDEX.

Page

Abbe, C., the annual parallax of *Sirius*, deduced from north polar distances, observed with the transit-circle, 1856–63, at the Royal Observatory, Cape of Good Hope 2
Abbott, F., on the variability of *η Argûs* and surrounding nebula 200
Airy, G. B., note on the total solar eclipse of 1868, August 17–18 17
Astronomische Gesellschaft, Meetings and Publications of 268
Astronomy, report on the progress of, in the year 1867–68 88

Barneby, T., *Jupiter* and his satellites 43
Baxendell, J., note on the variable star T *Serpentis* 45
Birt, W. R., on the lunar crater *Linné* 220
——, ——, observations of the lunar crater IV. A^{α} 17, IV. A^{ζ} 39 237
Brothers, A., on the name of the star ξ *Scorpii* (= Fl. 51 *Libræ*) 205
Browning, J., on the influence of aperture in diminishing the intensity of the colour of stars 34
———, —, on a contrivance for reducing the angular velocity of meteors, so as to facilitate the observation of their spectra 50
———, —, on some markings seen on *Venus* 179
———, —, on a persistent marking on *Jupiter* 213
Bruhns, C., ephemeris of Brorsen's Comet........................ 158, 221
Brunnow, F., ephemeris for the opposition of *Iris*, 1868, computed from his tables of *Iris* 47
Buckingham, J., on some newly discovered stars near *α Lyræ* 6
Burr, T. W., on *Jupiter* without satellites exterior to his disk............ 12

Chambers, G. F., a synoptical catalogue of known and suspected binary stars.. 174
Chary, C. Ragoonatha, occultations visible in August 1868.............. 193
Chimmo, W., meteoric shower, Nov. 1867, off Martinique 54
Comets, 1857, III. and V., and 1867. III., M. Hoek 129
Comet, Brorsen's, ephemeris of 158, 221
—— III. 1867, discovery 15
——, 1868 (Winnecke's) 243
Cooke, T., on a new driving-clock for equatoreals...................... 210
Crossley, E., observations of the lunar crater *Linné* 187

Davidson, J., description of a zenith telescope of U. S. Coast Survey...... 181
Dawes, Rev. W. R., description of an observing chair 9
———, ————, *Jupiter* without a visible satellite 10
———, ————, death of 163
De La Rue, W., Stewart and Loewy, result of the observations on sun-spots, made in Kew and at Dessau, during the year 1867.... 44
Drayson, Capt. W. W., remarks on the stellar longitudes assigned by Ptolemy 207

Page

Equatoreals, a new driving-clock for, Mr. Cooke 210
Eclipses and occultations, attempt to facilitate the prediction and reduction of, Mr. Penrose 33
Errata 16, 36, 56, 191, 224, 244, 272

Fasel, V., meteor epoch of Nov. 13–14, 1867 51

Fellows deceased, list of 64
  Lord Wrottesley 64
  Sir James South 69
  A. D. Bache (Associate) 72
  H. J. B. Nicholson 75
  M. Bland ib.
  J. J. Downes 76
  C. Howell 77
  W. Brooke ib.

Fellows elected 1, 17, 37, 57, 129, 165, 193, 225

Greenwich observations of occultations of stars by the Moon and phenomena of *Jupiter's* satellites, Jan. to Dec. 1867 172

Harrison, J. P., inductive proof of the Moon's insolation 39
Harvard observatory, notice of annals of 190
Herschel, Sir J. F. W., additional identifications of double stars in the synoptic catalogues of Sir William Herschel's micrometrical measurements, &c., with a list of errata 151
———, ———, on the variable star η *Argûs* and its surrounding nebula 225
Hoek, M., on the comets, 1857, III. and V., and 1867, III. 129
———, —, on the phenomena which a very extended swarm of meteors coming from space presents after its entry into the solar system 131

India, the North German expedition to 244
Iris, ephemeris of, for opposition, 1868, Mr. Brunnow 47

Joynson, J., the lunar crater *Linné* 49
———, —, occultation of γ *Tauri*, March 28, 1868 214

Jupiter without a visible satellite:—
  Mr. Burr 12
  Mr. Dawes 10

Jupiter and satellites, Mr. Barneby 43
———, a persistent marking of, Mr. Browning 213
Jupiter's satellites, phenomena of, observed at Greenwich, Jan. to Dec. 1867 172
——— ———, eclipses of, Mr. Tebbutt 215

Key, Rev. H. C., on the planetary nebula 45 H IV. *Geminorum* 154
Kingston observatory, Canada, latitude of, Dr. Williamson 12
Kirkwood, D., the meteors of Nov. 13–14, 1867, observed at Bloomington, Indiana 33
Knott, G., on the maximum of U *Geminorum* 46
———, —, companion to γ *Equulei* 47

Lowe, E. J., 14th November, 1867, meteor epoch 32
Loewy. See De La Rue, Stewart, and Loewy.
Lunar eclipse, Sept. 13, 1867, Capt. Noble 14
——— eclipses not noticed in the *Nautical Almanac*, Mr. Proctor 239

Lunar crater *Linné*:—
  Capt. Noble 48, 187
  Mr. Joynson 49, 126

Page

Lunar crater *Linné*:—
  Mr. Webb ... 185, 218
  Mr. Crossley ... 187
  Mr. Prince ... 219
  Mr. Birt ... 220

Lunar crater IV. A$^{\alpha}$ 17, IV. A$^{\zeta}$ 39, Mr. Birt ... 237

Luther, R., observations of planets (94), (95), (96), (97) ... 157

Maclear, G. H. W., meteoric shower at the Cape of Good Hope ... 51
Mars, rotation of, Mr. Proctor ... 37
Meteors, contrivance for observation of, Mr. Browning ... 50
———, phenomena presented by swarm of, M. Hoek ... 131
Meteors, November 1867: —
  Mr. Lowe ... 32
  Prof. Kirkwood ... 33
  Mr. Fasel ... 51
  Mr. Maclear ... ib.
  Comm. Chimmo ... 54
  Capt. Stuart ... ib.
Minor planets: —
  (92) *Undina*, discovery and elements ... 15
  (93), (94) discovery ... ib.
  (93), elements ... 35
  (94), (95), (96), (97), Dr. Luther ... 157
  (94), (95), elements of ... 191
  (96) *Œgle* ... 241
  (97) *Clotho* ... ib.
  (98) *Ianthe* ... 242
Minor Planet, discovery of, by Prof. Watson ... 271
Moon's insolation, inductive proof of, Mr. Harrison ... 39
——— mass, determination of, Mr. Stone ... 42

Nautical Almanac, on employment of a table in, for reducing lunar distances, Capt. Shadwell ... 168
Nebula, 45 ♅ IV. *Geminorum*, Mr. Key ... 154
——— in *Orion*, Father Secchi ... 162
——— surrounding η *Argûs*, Mr. Abbott ... 200
——— ———————, Sir J. Herschel ... 225
Newall, R. S. Note on Occultation of α *Tauri*, May 22, 1868 ... 156
Noble, Capt. W., occultations of stars by the Moon, observed at Forest Lodge, Maresfield ... 14
———, ———, note on the lunar eclipse of Sept. 13, 1867 ... ib.
———, ———, the lunar crater *Linné* ... 48, 187
Nutation, determination of constant of, from observations of *Polaris*, *Cephei* 51, δ *Ursæ Majoris*, at the Royal Observatory, Greenwich, 1851–65, Mr. Stone ... 229

Observations, rejection of discordant, Mr. Stone ... 165
Observatories, accounts of proceedings of: —
  Greenwich, Royal Observatory ... 78
  Edinburgh Royal Observatory ... 79
  Oxford, Radcliffe Observatory ... 79
  Cambridge ... 81
  Liverpool (new Observatory at Bidston, Birkenhead) ... 81
  Glasgow ... 83
  Kew ... 83
  Birr Castle (Lord Rosse) ... 85
  Cranford (Mr. De La Rue) ... 86
  Tulse Hill (Mr. Huggins) ... 86

Page

Observing chair, description of, Mr. Dawes 9
Occultations of stars by the Moon, Capt. Noble 14
——— Greenwich observations of, Jan. to Dec. 1867 172
——— visible in August 1868, Mr. Chary 193
——— *α Tauri*, May 22, 1868, Mr. Newall 156
——— *γ Tauri*, March 28, 1868, Mr. Joynson 214
——— and eclipses, on the prediction and approximate reduction of, Mr. Penrose 33

Penrose, F. C., an attempt to facilitate the prediction of occultations and eclipses, and the approximate reduction of the observed phenomena 246 33
Pihl, O., on the cluster in *Perseus* 246
Prince, C. L., on the lunar crater *Linné* 219
Proctor, R. A., rotation of *Mars* 37
———, ———, proposal for a new star atlas 188
———, ———, on certain partial lunar eclipses not noticed in the *Nautical Almanac* 239
Ptolemy, on his stellar longitudes, Capt. Drayson 207

Recent Publications 271
Refractions, Bessel's mean, Mr. Stone 25

Secchi, Father, the great nebula in *Orion* 162
———, ———, a catalogue of spectra of red stars 196
Shadwell, Capt., note on the employment of the table given in the *Nautical Almanac*, showing the correction required on account of second differences in finding the Greenwich time, corresponding to a reduced lunar distance 168
Simms, J., description of a zenith telescope 161
Sirius, annual parallax of, deduced from north polar distances observed, 1856–63, at the Cape of Good Hope, Mr. Abbé 2
Society :—
  Report of Council to forty-eighth annual meeting 57
  List of papers, Feb. 1867 to Feb. 1868 100
  Library, list of donors to 103
  President's address on delivery of medal to M. Leverrier 110
  Officers and Council for 1868–69 125
Solar eclipse, Aug. 1868, Mr. Airy 17
———, ———, Mr. Stoney 18
———, ———, Major Tennant 245
Solar parallax, remarks on value of, as deduced from the parallactic inequality in the earth's motion, Mr. Stone 21
——— See *Venus*, transit of, 1769.
Star atlas, proposal for new, Mr. Proctor 188
Stars, colours of, as affected by aperture, Mr. Browning 34
——, spectra of red, catalogue of, Father Secchi 196
——, *α Lyræ*, newly discovered stars near, Mr. Buckingham 6
——, *γ Equulei*, companion of, Mr. Knott 47
——, *ξ Scorpii*, (= Fl. 51 *Libræ*), on the name of, Mr. Brothers 205
——, *Perseus*, cluster in, Dr. Pihl 246
——, double, Sir W. Herschel's catalogue of, identifications and errata, Sir J. Herschel 151
——, ———, catalogue of known and suspected, Mr. Chambers 174
——, variable, T *Serpentis*, Mr. Baxendell 45
——, ———, U *Geminorum*, Mr. Knott 46
——, ———, *η Argûs*, and surrounding nebula, Mr. Abbott 200
——, ———, ———, Sir J. Herschel 225
——, ———, ———, Mr. Tebbutt 266
Stewart, B. See De La Rue, Stewart, and Loewy.
Stone, E. J., some remarks on the value of the solar parallax, as deduced from the parallactic inequality in the earth's motion 21

Page
Stone, E. J., on Bessel's mean refractions 25
——, ——, a determination of the Moon's mass 42
——, ——, on the rejection of discordant observations 165
——, ——, a determination of the constant of nutation, from observations in N.P.D. of *Polaris*, *Cephei* 51, and δ *Ursæ Minoris*, made with the transit circle of the Royal Observatory, Greenwich, 1851–65 229
——, ——, rediscussion of the observations of the transit of *Venus*, 1769 255
Stoney, J., on the solar eclipse, August 1868 18
Stuart, Capt., meteoric shower, Nov. 1867, at Nassau, Bahamas 54
Sun-spots, observations of, at Kew and Dessau, Messrs. De La Rue, Stewart, and Loewy 44

Tebbutt, J., eclipses of *Jupiter's* satellites, observed at Windsor, New South Wales 215
——, —, on the variability of η *Argûs* 266
Tennant, Major, observations of the zodiacal light 214
——, ——, the total solar eclipse of Aug. 17–18, 1868 245
Telescope, achromatic, the invention of, M. Wackerbarth 202
——, zenith, description of, Mr. Simms 161
——, ——, U. S. coast survey, Mr. Davidson 181
——, presented to the Society by Mr. Baker 242

Venus, markings in, Mr. Browning 179
——, lustre of, Mr. Weston 180
——, transit of, 1769, Mr. Stone 255

Wackerbarth, A. D., questions relative to the original inventor of the achromatic telescope 202
Watson, Prof., Observation of a minor planet, discovered at Ann Arbor Observatory 271
Webb, Rev. J. W., observations of the lunar crater *Linné* 185, 218
Weston, C. H., on the lustre of *Venus* 180
Williamson, Rev. J., determination of the latitude of Kingston Observatory, Canada 12
Winnecke, A., observation and elements of comet 243

Zodiacal light, observations of, Major Tennant 214

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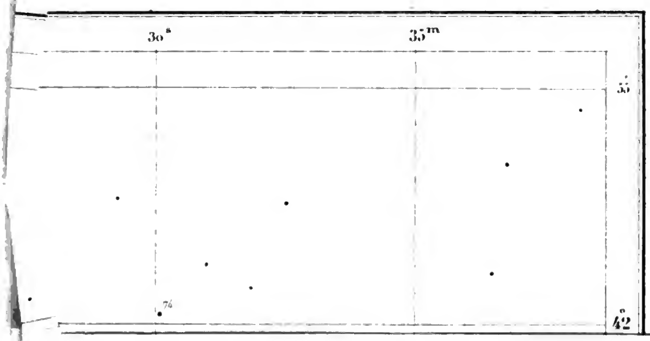
30ˢ
35ᵐ
55
74
42

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